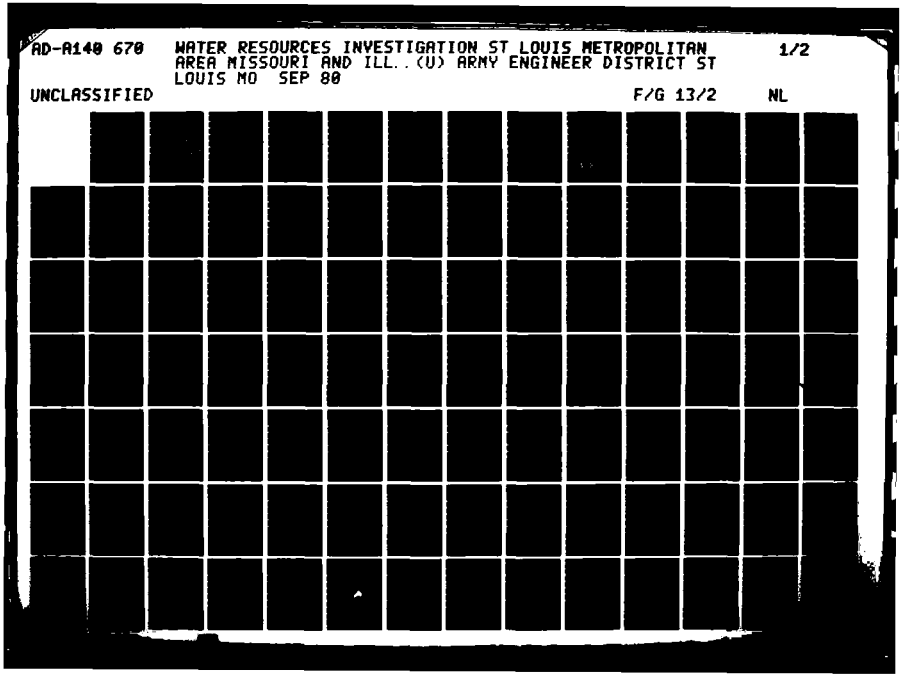
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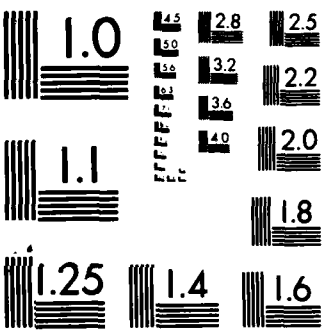

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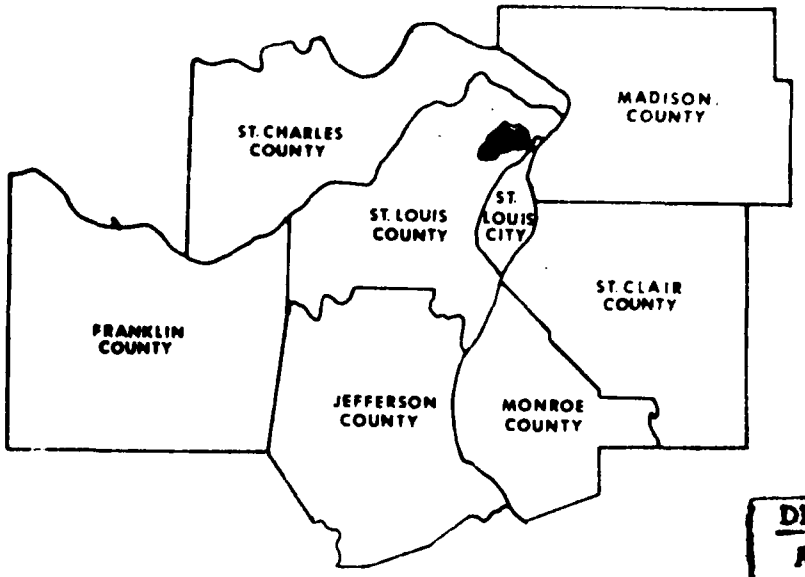
MALINE CREEK, MISSOURI
SURVEY REPORT



VOLUME ONE
MAIN REPORT

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
SEPTEMBER 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. A140670 — 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Maline Creek, Missouri Survey Report for Flood Control and Allied Purposes Water Resources Investigation St. Louis Metropolitan Area, Missouri and Illinois Vol One, Main Report	5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis 210 Tucker Blvd., N. St. Louis, MO 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE Sept 1980 13. NUMBER OF PAGES 104
14. MONITORING AGENCY NAME & ADDRESS*(If different from Controlling Office)*	15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

public

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report recommends an environmentally designed, outdoor recreation-oriented solution to the flooding problems along Maline Creek. Maline Creek is best described as an urban storm sewer. The stream's natural features have been essentially eliminated by intense urbanization. The 25 square mile study area is located from the Lambert St. Louis International Airport, eastward through urbanized St. Louis County and the city of St. Louis, Missouri, to the

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Mississippi River. The object of this study is to identify comprehensively all alternative options and to recommend a solution to the problems normally associated with urban stormwater sewers such as: flooding; streambank erosion; lack of outdoor recreation; and, environmental degradation.

WATER RESOURCES INVESTIGATION

ST. LOUIS METROPOLITAN AREA, MISSOURI AND ILLINOIS

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

VOLUME ONE

MAIN REPORT

VOLUME INDEX

MALINE CREEK

EXECUTIVE SUMMARY

This report recommends an environmentally designed, outdoor recreation-oriented solution to the flooding problems along Maline Creek. The many technical studies leading to the recommendations contained within this report originated in 1968. The original Maline Creek natural emphasis approach was ahead of its time. Federal regulations and national policy have experienced a major environmental evolution in the 1970's which now allow favorable processing of the Maline Creek report.

Maline Creek is best described as an urban storm sewer. The stream's natural features have been essentially eliminated by intense urbanization. The 25 square mile study area is located from the Lambert St. Louis International Airport, eastward through urbanized St. Louis County and the city of St. Louis, Missouri, to the Mississippi River. The object of this study is to identify comprehensively all alternative options and to recommend a solution to the problems normally associated with urban stormwater sewers such as: flooding; streambank erosion; lack of outdoor recreation; and, environmental degradation.

A great deal of active public participation has been of immense help in each stage of this study's progress. The study's problem identification stage, creation of all possible alternative solution stage and even the technical study stages all benefited a great deal from persistent public participation. The tenacity of the volunteer "Stormwater Committee" in its monthly meetings since November 1974 is to be commended.

The selection of the environmental quality (EQ) plan as the alternative to be recommended was, and remains, fully dependent on continuing public interest, participation and support. The recommended plan, which is the EQ plan, has been selected because it enjoys widespread public support and also displays the ability to concurrently satisfy most of the flood control, outdoor recreation and environmental needs of the area. Many different techniques were used to evaluate and compare the performance of all alternative plans. The recommended plan is expected to perform very well by: largely solving existing flooding problems (i.e., 90% reduction in average annual flood damages); preventing future expansion of flood plain urbanization (i.e., the entire undeveloped 10 year flood plain area will remain in its current open state), thus further decreasing future flood damages; capturing the available opportunities to address existing and projected outdoor recreation deficiencies (i.e., 10 miles of trails plus other features provided); preserving existing environmental amenities; addressing existing and future environmental degradation problems; and, enhancing the natural terrestrial and aquatic area characteristics thereby significantly improving the area's plant, animal, fish and fowl habitats while also improving the human habitation environmental setting.

The recommended environmental quality plan is composed of the following features:

a. 8 dry detention sites

b. 3.29 miles of channel widening and straightening

c. 5.05 miles of low level floodwalls

d. 3.31 miles of low level levees

e. 91 acres of clearing

f. 5 bridge replacements

g. 2 bridge improvements

h. 18 aquatic habitat structures

i. 5 fish ponds

j. 384 acres of open space adjacent to detention basins plus 474 acres along the stream corridor

k. 10 miles of environmental/recreational trails

The recommended plan of improvements is estimated to cost $43,800,000 based on October 1979 price levels. These costs would be shared $31,030,000 Federal, $10,580,000 local sponsor, and $2,190,000 state of Missouri. Average annual costs divided by average annual tangible benefits yield a tangible benefit to cost ratio of 1.35 to 1. However, it is considered that a considerably higher, but unquantifiable, benefit to cost ratio actually exists due to the significant intangible worth associated primarily with the environmental enhancement features of the recommended plan.

MALINE CREEK, MISSOURI
SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

MAIN REPORT

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ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

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September 1980

MALINE CREEK, MISSOURI
SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

INTRODUCTION

This report presents a coordinated plan for flood control, environmental, and outdoor recreation improvements. The plan enjoys very wide ranging and active support by local citizens, elected officials, local agencies, environmental groups, the state of Missouri and all known interested Federal agencies.

STUDY AUTHORITY

This study responds to six Congressional resolutions dated: 7 April 1966 (Senate); 4 October 1966 (Senate); 15 July 1970 (Senate); 29 July 1971 (House of Representatives); 2 October 1972 (Senate); and 12 October 1972 (House of Representatives). These resolutions also authorized the St. Louis District, Corps of Engineers' comprehensive regional study entitled, "St. Louis Metropolitan Area, Missouri and Illinois, Study" (Metro Study) of which Maline Creek is an interim report. The complete text of these authorizing resolutions is contained in APPENDIX A.

SCOPE OF THE STUDY

This report focuses on the flood control, environmental, and outdoor recreation needs/opportunities of the Maline Creek area, Missouri. A location map is shown as PLATE 1.

STUDY PARTICIPANTS AND COORDINATION

The Corps of Engineers has sole responsibility for this study. Active public involvement and interagency coordination were used to help ensure realistic plan formulation in this complex urban setting. A three-level public participation and agency coordination program was used to help provide maximum local input. This three-level technique was used to coordinate the study progress with all appropriate Federal, state, and local agencies, as well as interested public groups and individuals. The functions of three levels of coordination were as follows:

1. Level 1 coordination included organizations that have broad regional interests, significant technical expertise, and important socio-political input. The following agencies were asked to participate in the study: the Metropolitan St. Louis Sewer District (MSD); the East-West Gateway Coordinating Council; St. Louis County; Bureau of Outdoor Recreation; Soil Conservation Service; United States Geological Survey; Forest Service; Department of Housing and Urban Development; United States Fish and Wildlife Service; National Park Service; United States Coast Guard; Federal Highway Administration; Federal Aviation Administration; Federal Power Commission; Environmental Protection Agency; and the state of Missouri. Since creation of the Federal Emergency Management Agency and identification of its areas of responsibility, that agency has been asked to review and participate in this study. In addition to providing valuable review comments, the Environmental Protection

Agency conducted a Maline Creek water quality study; the Bureau of Outdoor Recreation supplied assistance with recreation analyses; the Soil Conservation Service conducted a soils mapping program for the Maline Creek watershed; and the United States Geological Survey supplied recorded rainfall and stream flow data. In addition, the MSD, the East-West Gateway Coordinating Council, St. Louis County, and the Corps of Engineers formed an informal organization called the "Maline Creek Guidance Committee." Throughout the planning process, this guidance committee met to discuss the problems and alternative plans of improvement and to provide input towards shaping the final recommendation.

2. Level 2 coordination included organizations and groups with a more limited jurisdiction or special interest. This group includes municipally elected officials, professional engineering and planning groups, and environmental groups. Meetings were held to keep this level informed on the progress of the study. A storm water committee of professional eningeering, professional planning and citizen representatives continues to meet once each month since 26 November 1974.

3. Level 3 involves the directly affected individual citizens and neighborhood groups. Input from this level, as well as from levels 1 and 2, was formally received at public meetings held on 14 June 1968 and 18 October 1972, as well as informally received from numerous individual and field contacts. The informal meetings were particularly effective in providing a mechanism for two-way communications with affected individuals and organizations. Input obtained in this manner was essential to identify problems, needs, impacts, and conduct evaluations. A final public meeting was held 15 July 1980 to provide all local regional and national interests with the results of the extensive studies, formulation and public participation and to obtain final concurrence on a recommended plan of improvements.

STUDIES OF OTHERS

No prior reports have been prepared by the Corps of Engineers addressing the entire Maline Creek watershed. However, a report was prepared by the St. Louis District, Corps of Engineers, on improvements at the mouth of Maline Creek as part of the city of St. Louis and Vicinity, Missouri, project. That report was prepared in response to a resolution adopted on 20 April 1948 by the United States Senate, Committee on Public Works. Other reports discussing the lower Maline Creek area in relation to the city of St. Louis project are: Senate Document No. 57, 84th Congress, 1st Session; Design Memorandum No. 4, General Design, Corps of Engineers, October 1957; Preliminary Investigation-Flood Protection Along Maline Creek-City of St. Louis and Vicinity, Missouri, Corps of Engineers, June 1961; and Flood Protection-St. Louis, Missouri, Design Memorandum, Flood Walls, Levees, and Pumping Station, Reach 3, Maline Creek-Area B, FRUCO and Associates, 1963.

Maline Creek lies within the area addressed by the Corps of Engineers' study entitled, "St. Louis Metropolitan Area, Missouri and Illinois, Study" (Metro Study) dated September 1977.

Other Federal agencies have participated in water resource oriented work efforts in the Maline Creek watershed. The Department of Housing and Urban Development has provided funds to channelize portions of Maline Creek, reroute other portions, and encase portions of a tributary in underground pipes. These efforts were accomplished in order to handle immediate problems of a very localized nature and have no major impact on the recommendation made herein. At the local level, information provided by the MSD and St. Louis County was extremely helpful during the course of this investigation. In addition, flood insurance studies for the following municipalities within the Maline Creek watershed have been

completed as of September 1980: Bellefontaine Neighbors, Bel Ridge, Berkeley, Black Jack, Cool Valley, Ferguson, Florissant, Jennings, Kinloch, Moline Acres, Overland, and Vinita Park. The St. Louis County Department of Parks and Recreation has prepared a "Linear Park Project" plan. This plan includes an outdoor recreation and environmental improvement proposal for the Maline Creek area compatible with the proposal made herein.

Under the authority of Public Law 256, 84th Congress, 1st Session, the Corps of Engineers constructed a levee near the mouth of Maline Creek that starts on the right bank near Riverview Drive and extends in an east-southeast direction towards the Mississippi River (mile 187.2) where it turns and continues in a southerly direction. This levee is part of a system designed to protect the city of St. Louis, from the mouth of Maline Creek south to the extension of Chippewa Street, against a 52-foot Mississippi River flood stage.

The Corps of Engineers has the authority under Section 14 of the 1946 Flood Control Act to undertake emergency stream bank and shoreline protection of public works and non-profit public services. This authority was used to construct improvements adjacent to the Meadows School located along Blackjack Creek (Tributary MD) near Chambers Road. These improvements have been installed.

Local interests have constructed channel improvements which are primarily located on the tributaries of Maline Creek.

THE REPORT AND STUDY

This report is presented in three volumns. Volume One consists of the main report and necessary plates. Volume Two consists of the text of all appendices, and Volume Three contains all appendix plates. The main report summarizes the logic of the planning

process and its conclusions. A concise Environmental Impact Statement (EIS) is a functional part of the main report in order to more clearly present the environmentally integrated Maline Creek planning process. The Maline Creek planning process is based on a series of sequential iterations of four functional planning tasks (i.e., problem identification, formulation of alternatives, impact assessment, and evaluation). This planning process was completely repeated four times, with increasing accuracy and detail.

The four cycles of plan formulation focused on the development and evaluation of alternative realistic plans of improvement. This study's plan formulation technique accomplished the following:

a. Concurrent tangible and intangible impact analysis;

b. Application of a series of screening criteria so as to create single-purpose oriented alternative solutions that then served as fundamental components for the preparation of multi-purpose alternative system solutions;

c. Designation of the National Economic Development (NED) plan, the Environmental Quality (EQ) plan, a "traditional" plan, a nonstructural plan and a "conventional" plan from the 517 alternative potential plans available; and

d. Selection of one plan as the recommended plan.

PROBLEM IDENTIFICATION

The principal water and related land resources needs of the Maline Creek watershed are for flood control (i.e., significant flood damage mitigation), increasing outdoor recreation opportunities, and enhancing the watershed's environmental quality.

NATIONAL OBJECTIVES

The national water and related land resource planning objectives which served as general guide posts for this study are:

1. To enhance national economic development, and
2. To enhance the quality of the natural environment.

Specific to the Maline Creek flood plain area, the national goal is sound flood plain management that embodies the wise use, conservation, development, and utilization of interrelated land and water resources to serve the objectives of economic efficiency, environmental quality, and social well-being. It is the policy of the Corps of Engineers to formulate projects which, to the extent possible, avoid or minimize adverse impacts associated with use of the base flood plain and avoid inducing development in the base flood plain unless there is no practicable alternative. In a message to Congress of 6 June 1978, the President directed that the national water policy should be improved by "requiring the explicit formulation and consideration of a primarily nonstructural plan as one alternative, whenever structural water projects are planned." The President has emphasized a commitment to national economic development (NED) and environmental quality (EQ) as basic national planning objectives.

EXISTING CONDITION PROFILE

The 16,170-acre (25-square mile) Maline Creek watershed is highly urbanized. This area includes a small northern part of the city of St. Louis, portions of unincorporated St. Louis County, and all or parts of 22 municipalities. Maline Creek has 36.2 miles of streams consisting of 10.6 miles of main channels with 10 major tributaries. The lengths of tributaries vary from 1.4 to 4.2 miles. The Maline Creek watershed has relatively gently sloping surfaces, with a local relief of less than 300 feet. The slope of the longest portion of Maline Creek is about 1 foot of vertical drop in a 220-foot distance. Maline Creek flows in a southeasterly direction into the Mississippi River, approximately 8 miles downstream from the confluence of the Mississippi and Missouri Rivers.

Water quality in Maline Creek and its major tributaries ranges from fair to poor. Objectionable chemical indicators including pH, dissolved oxygen, nutrients, chloride, and heavy metals were measured during studies conducted for this report. Aquatic organisms sampled from several sites within the watershed are generally pollution tolerant. Invertebrate groups commonly regarded as clear water forms are absent from aquatic organism samples taken.

Most of the natural vegetation has been replaced by urban vegetation. The remaining natural vegetation is mostly forest cover concentrated in the northern portion of the watershed on steep slopes and along stream courses. The largest amount of vegetative cover (77 percent of the watershed) is of a mixed suburban type. This cover varies in wildlife habitat value from the low-valued monoculture of lawns to a relatively high-value, diverse interspersion of trees, grass, and shrubs.

The Maline Creek watershed contains no important habitat for species either considered threatened, endangered, or rare either by the U. S. Department of the Interior or the state of Missouri. No Federally-classified threatened or endangered plants occur in the watershed. On occasion, an animal of either Federal or state unique classification (especially migratory bird species) may be found in the watershed.

During a comprehensive cultural resource study conducted in 1976, only one archaeological site was identified. This site was identified by the discovery of a single chert flake and is considered to be of no National Register significance. Extensive urbanization has destroyed all but an insignificant portion of the archaeological record.

Four local historic resources have been identified. These sites are the Bissel House, which has been nominated to the National Register of Historic Places; the Bellefontaine Methodist Church; the Wildwood House; and the Ferguson House. None of the latter three sites are on the National Register or are presently being proposed.

In 1970, the watershed's population was 125,330 which is a 20 percent increase from 1960. In comparison to the major adjacent population centers, the 1970 population was 13 percent of the total St. Louis County population and five percent of the St. Louis metropolitan area population. The civilian labor force consisted of 16,200 employees in 1970 with about 96 percent employed at that time.

Land use is predominantly residential. Of the total 16,170 acres, over 62 percent fell into the residential category as of 1975. During the period 1957-1975, extensive development of agriculture-vacant land occurred with residential land use representing the largest increase. The primary catalyst for this

increase in development was the growth and improvement of the transportation network over the years.

CONDITIONS IF NO FEDERAL ACTION IS TAKEN (WITHOUT CONDITION PROFILE)

Future land use for the without project condition came from the St. Louis County Department of Planning's "General Plan." This plan represents projected conditions for the year 2020 and has been adopted by the St. Louis County Government. TABLE 1 displays a comparison between the 1975 and 2020 land use categories and indicates that the development trend is expected to continue until less than 5 percent of the land will remain undeveloped by the year 2020.

TABLE 1
MALINE CREEK
1975 AND 2020 LAND USE

Category	1975		2020	
	Acres	% of Total	Acres	% of Total
Residential	10,141	62.7	11,070	68.4
Commercial-Industrial	1,145	7.1	1,900	11.8
Institutional-Recreation	2,062	12.8	2,460	15.2
Agriculture-Vacant	2,821	17.4	740	4.6
TOTAL	16,170	100.0	16,170	100.0

The projected 2020 population for the Maline Creek watershed is 168,000. Employment is projected to increase from 16,200 in 1970 to 29,500 by 2020, and per capita income to increase from $3,776 in 1970 to $13,900 by 2020 (1967 constant dollars).

PROBLEMS, NEEDS, AND OPPORTUNITIES

The problems, needs, and opportunities relative to flooding, outdoor recreation, and environmental quality are summarized in the following paragraphs. A more detailed analysis is presented in APPENDIX A.

Flood Problems

The principal flood problem in the Maline Creek watershed is flash flooding caused by high intensity rainfall. Low intensity, long duration storms generally will not cause extensive flooding because of the watershed's topography and extensive drainage system. The severe storms that produce the high intensity rainfall are most likely to occur during a 4-month period from May through August. The highest recorded flood in this watershed occurred 14-15 June 1957. Although no specific historic damage data are available for this event, it is estimated that if a storm equal in intensity to this event would occur under existing conditions, nearly $21,000,000 in damages would result (1976 prices and condition). This level of damages was not experienced in 1957 because most urban flood plain development has occurred since 1957. In April 1979 severe flooding occurred in the Maline Creek watershed. A $2,500,000 loss was experienced due to Mississippi River backwater plus an additional $16,500,000 damages due to Maline Creek headwater flooding. The principal flood damageable items are residential structures and contents. Under existing conditions, the occurrence of a 100-year flood event would cause inundation damages to 2,527 residences and 56 commercial/industrial structures. Total residential and commercial/industrial damages from a flood of this magnitude would be $17,923,000. A standard project flood (SPF) under these same conditions would cause damages of $38,050,700. The area that would be inundated by these two events is shown in APPENDIX D. TABLE 2 presents a without-project summary of flood damage information for both existing and future conditions. The future conditions time frame adopted for this study is 1990 to 2090.

TABLE 2
MALINE CREEK
FLOOD DAMAGE SUMMARY

Event	Residential Units Inundated	Com.-Ind. Units Inundated	Total Damages ($1,000)
100-year (existing)	2,527	56	$17,923
SPF (existing)	3,487	67	38,051
100-year (future)	2,550	60	20,809
SPF (future)	3,544	69	45,409

Equivalent average annual damages for existing and future without-project conditions are $3,447,500 and $4,145,000, respectively. The extent of flooding problems resulting from the Mississippi River acting upon the watershed are very minor ($15,600 average annual damages, existing conditions). The consequences of coincidental flooding of the Mississippi River and Maline Creek are essentially the same as flooding by the creek itself. Economic losses related to flooding are important factors for identifying the magnitude of the problem. However, they are only a partial indication of the flood hazard. Because of the nature of flooding within this watershed (flash flooding), the potential for loss of life is much higher than if flood stages were produced more gradually.

Outdoor Recreation Needs

A detailed analysis of recreation needs for both existing and future conditions indicates that these needs are (and will be) only partially satisfied. Increased development in this watershed over the years has diminished the available supply of land for recreation pursuits and has increased the number of recreation facility consumers (residents). Future land use and population projections for this watershed indicate that this trend is expected to continue. The present (1970) outdoor recreation acreage is 737 acres. The present (1970) unmet need for recreation land is 515 acres. By the year 2020, this existing unmet need is expected to increase to 943 acres. In terms of recreation activities, needs have been identified for swimming, fishing, organized camping, bicycling, horseback riding, backpacking, outdoor games, tennis, and picnicking. In addition to the needs discussed above, local officials have indicated a desire to improve access to and linkages between existing parks through the acquisition of linear trailways and recreation corridors.

Environmental Quality Needs

Water supply needs for the Maline Creek watershed were investigated as part of the Metro Study. It was concluded that there are no significant Maline Creek water supply problems or needs. Other environmental quality needs that were investigated are erosion, water quality, aquatic community improvement, terrestrial community improvement, litter/debris control, and noise abatement. These needs are summarized below.

Erosion. Local officials and residents have expressed a need for erosion control, primarily in areas where property is located very close to the stream. The natural erosion and caving of the stream bank cause unquantified damages to property and also increase the hazards to health and safety by creating dangerous, sheer banks as high as 25 feet along some reaches of the main channel.

Water Quality. As discussed earlier in this report, water quality varies from fair to poor. However, it is assumed that the existing need to improve water quality conditions will be satisfied through the enforcement by other agencies of all Federal and state clean water laws. As a result, this problem was not specifically addressed further by this study. It is considered that this assumption is well justified in view of this study's more distant time frame (i.e., 1990 to 2090), as compared to more immediate Federal clean water deadlines.

Aquatic Community Improvement. Two unquantifiable aquatic community needs exist within Maline Creek: increased species diversity and increased habitat diversity. The low species diversity problem is primarily due to poor water quality. As water quality improves through the enforcement of clean water standards, this problem is expected to diminish. However, the existing surface drainage system

would still limit the potential for expanded numbers and types of aquatic life. An unmet need for increased aquatic habitats is expected to continue to exist.

Terrestrial Community Improvement. In addition to aquatic communities, terrestrial community needs have been identified. Extensive urbanization within the watershed has reduced the amount of undeveloped areas that are the primary habitats for terrestrial wildlife. As with aquatic communities, this problem is essentially unquantifiable. Local and state officials have expressed a need to preserve and improve the existing habitats.

Litter and Debris Control. Another need related to the environment is litter and debris control in and along the stream corridor. The problem of large debris within the channel that causes hydraulic impediments is handled by the MSD's on-going channel maintenance program. However, a need exists to better control the dumping and littering in order to improve the watershed's aesthetic and environmental quality.

Noise Abatement. Intrusive noise levels were discussed earlier in this report. Because of the expected increase in noise levels as urbanization increases, a need was identified to reduce noise to non-intrusive levels. The formulation process used for this study screened alternative plans of improvement on the basis of noise minimization as described in APPENDIX B.

PLANNING CONSTRAINTS

A number of specific criteria were established in the technical, economic, environmental, and evaluation fields to aid in practical plan formulation. These criteria were in essence constraints placed upon the plan formulation process. These planning constraints are

discussed below. During the fourth (i.e., last) cycle of plan formulation, a group of additional formulation criteria were established as also discussed below.

Technical Criteria

Technical criteria are the practical guidelines that directly affect physical design features. The technical criteria relate primarily to sound engineering practice. The technical criteria established for this study are as follows:

a. The components of the recommended plan must be realistic;

b. Equal consideration will be given to nonstructural and structural approaches during plan formulation;

c. All nonstructural and/or structural measures recommended must be practical from an engineering standpoint and implementable under the specific site conditions; and

d. All nonstructural and structural measures implemented must not impede any potential future flood fight efforts. That is, they must not make flood fighting conditions more difficult.

Economic Criteria

Specific economic criteria were used to analyze alternative plans developed during this study. The economic criteria are as follows:

a. All work through 1979 was based on the then applicable Federal criteria which was that tangible benefits must exceed project costs. Since that time, Federal policy has changed and now only requires that the sum of tangible plus intangible benefits must

exceed project costs. This change in Federal policy has no real impact on this study's formulation because many alternative solutions have been analyzed that successfully satisfy even the original more austere criteria, and thus easily pass the current Federal criteria.

b. Each separable unit of improvement shall provide tangible plus intangible benefits, at least equal to its costs.

c. The scope of development shall be such as to provide the maximum net benefits when realistically possible and should not be significantly detrimental to intangible considerations.

d. There shall be no more economical means of accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken. This limitation refers only to those alternative possibilities that would be physically displaced or economically precluded from development if the project is undertaken.

e. All analyses will be based on current price levels.

f. Annual costs will be based on a 100-year period of analysis.

g. All average annual calculations will be based on the prevailing annual interest rate.

Environmental Criteria

Environmental criteria were established to insure that the environmental quality of the Maline Creek watershed receives equal emphasis with economic efficiency during the formulation of the alternative plans. The following criteria were used as guidelines during the formulation process:

a. The natural environment will be protected and enhanced wherever possible.

b. Should the imposition of detrimental environmental impacts be unavoidable, appropriate mitigation measures will be included.

c. The protection and enhancement of public health, safety, and social well-being will be maximized wherever realistically possible.

Evaluation Criteria

In order to provide a means for testing and evaluating relative plan performance, specific evaluation criteria were developed. The nine criteria are discussed below.

a. Assess the workability and viability of the plan regarding its acceptance by the affected publics and its accommodation of known institutional constraints (acceptability test).

b. Appraise the technical performance of the plan and the level of contribution to the planning objectives (effectiveness test).

c. Analyze the likelihood of the plan meeting all planning objectives as well as the contributions to the National Economic Development (NED) and Environmental Quality (EQ) accounts (certainty test).

d. Determine the capability of restoring the completed works to the without-condition should public needs or values change in the future (reversibility test).

e. Analyze the sensitivity of the plan to potential developments in the future (stability test).

f. Assess whether all necessary investments or other actions necessary to assure full attainment of the plan are included (completeness test).

g. Determine if the area encompassed by the plan is large enough to allow a full understanding of the problem and specific enough to make the plan effective (geographic scope test).

h. Determine the economic viability of the plan (NED benefit-to-cost ratio test).

i. Assess the plan's ability to achieve the planning objectives in the least costly way (efficiency test).

Additional Formulation Criteria

The planning process during the fourth (i.e., last) iteration used an update of the previous revised formulation rationale and screening process. Corps of Engineers' review of the results of the third iterative cycle of plan formulation indicated that improvements in flood control performance were necessary. Therefore, the formulation criteria shown below were adopted so as to refine and improve the plan formulation screening. However, the best alternative plan derived from the third cycle of formulation which is called the "conventional" plan, was carried through the entire analysis in order to insure the widest possible array of potential alternatives in the final selection process. For the same reason, a nonstructural plan and a "traditional" plan alternative were carried through to final decision making even though not fully passing all screening criteria.

a. Average annual net induced damages will not exceed $10,000.

b. A minimum level 10-year frequency flood protection must be provided for each improved stream reach. A 10-year frequency flood event is defined as a flood having a 10 percent chance of occurrence in any one particular year.

c. No improvements were proposed that could create significantly hazardous or catastrophic situations in the event of unexpected failure of those improvements. In other words, great care was exercised to avoid proposing any improvement that may result in a "safety trap."

d. In order to provide a conservative margin of economic justification, all plans of improvements were screened on a minimum performance criterion of 1.2 benefit to cost ratio. These austere criteria are intended to help assure that the final proposal is economically sound even with uncertain future socio-economic conditions.

PLANNING OBJECTIVES

The watershed's problems and needs are discussed in detail in APPENDIX A. The study team's analysis of these problems and needs led to the establishment of the following planning objectives for this study:

1. Reduce the economic losses and social disruption caused by flash flooding along Maline Creek (i.e., significantly mitigate flood losses both economic and social).

2. Increase outdoor recreation opportunities.

3. Maintain the existing aesthetic and environmental qualities of the watershed, and where possible improve and enhance the environment.

FORMULATION OF PRELIMINARY PLANS

Four comprehensive cycles of the iterative plan formulation process were utilized to arrive at a recommended plan of improvements. Each successive cycle used an improved and more stringent group of screening criteria. A generalization of the plan formulation screening process that led to the selection of the recommended plan of improvements is shown in TABLE 3. The specifics of this work effort are provided in detail in APPENDIX B. The management measures available to solve the needs remained generally constant throughout the study process. Emphasis shifted between management measures as performance criteria improved for each cycle. The paragraphs following provide a brief summary of the highlights of the formulation of 517 plans leading up to selection of the recommended plan of improvements.

TABLE 3
MALINE CREEK
PLAN FORMULATION OUTLINE

I First Formulation Cycle

- A. Identify Problems and Needs
- B. Create Polar Solutions (i.e., Structural versus Natural)
- C. Identify a Compromise Solution that has Active Public Support
- D. Three Alternative Solutions Were Created in Cycle One Formulation

II Second Formulation Cycle

- A. Verify Problems and Needs
- B. Determine Planning Objectives
- C. Check Formulation Criteria and Assumptions
- D. Correct the Benefits Creditable to the Polar Solutions and the Compromise Solution
- E. Verify the Intense Public Support
- F. Basically, the Same Three Alternative Solutions Were Simply Improved in Cycle Two Formulation

TABLE 3 (Continued)
MALINE CREEK
PLAN FORMULATION OUTLINE

III Third Formulation Cycle

A. Verify Problems and Needs
B. Define Planning Objectives
C. Define Formulation Criteria, Assumptions, and Approach
D. Identify All Plausible Measures to Address Each Planning Objective
E. Screen, Refine, and Improve Single-Purpose Performance
F. Develop Multi-Purpose Alternatives
G. Designate Draft NED, EQ, and "Conventional" Plan
H. 137 Alternatives Were Created in Cycle Three Formulation

IV Fourth Formulation Cycle

A. Verify Local Citizen and Local Sponsor Desires
B. Update Formulation Criteria
C. Formulate 374 Additional Alternatives to Meet All Revised Criteria
D. Also Carried Through This Last Formulation Cycle was the Cycle Three "Conventional" Plan Plus a Nonstructural Plan and a "Traditional" Plan Even Though They Did Not Pass All Screening Criteria.
E. Designate an NED, EQ and Recommended Plan.
F. A Total of 377 Plans Were Studied in Cycle Four Formulation.

MANAGEMENT MEASURES

With the planning objectives, criteria, and assumptions serving as the basic foundation for the formulation effort, the next step was to identify the available improvement measures. The applicable water resources "management measures" identified to address the planning objectives for this study are:

1. Temporary evacuation
2. Permanent evacuation
3. Flood plain regulations
4. Warning signs

5. Tax concessions
6. Land acquisition
7. Aquatic habitat structures
8. Floodproofing
9. Debris control
10. Levees and floodwalls
11. Detention basins
12. Channel modifications
13. Diversions
14. Watershed treatment
15. Wildlife management
16. Outdoor recreation improvements

PLAN FORMULATION RATIONALE

The Maline Creek plan formulation rationale is based on the sequential determination and accomplishment of the following steps: identification of the watershed's problems and needs; establishment of the planning objectives; identification of the formulation criteria and assumptions; and then identification of the water resources management measures available to address the planning objectives. Each of these steps is summarized in the following paragraphs. A detailed discussion is contained in APPENDIX B.

The problems, needs, and objectives are discussed earlier in this report. The plan formulation rationale used identified specific formulation criteria and assumptions to establish the basic rules for the plan formulation effort. Formulation assumptions were then identified for both the future without, and future with, conditions. The assumptions documented were grouped under the following headings for convenience of presentation: general, flood protection, flood insurance program, land development, population, economic development, environment, community cohesion, and recreation. The details of this analysis are presented in APPENDIX B.

FIRST FORMULATION CYCLE

The first formulation cycle resulted in a draft Maline Creek Survey Report dated July 1973. This initial formulation iteration was designed to be rapid and innovative, while also being fully responsive to local desires. The report achieved those objectives. However, the rapid analysis did not provide the level of detailed planning, hydrology, and engineering needed to be successfully processed. Only two "polar" comprehensive alternative potential plans and a compromise draft recommended plan of improvement were identified. The details of this unsuccessful report are summarized in APPENDIX B.

SECOND FORMULATION CYCLE

The second formulation cycle was a brief one resulting in a draft Maline Creek report dated January 1974. This report was founded upon the earlier July 1973 report. The basic difference in the two reports was that the second report corrected the innovative benefits analysis. The result was that the benefit-to-cost ratio dropped from 1.5 to 0.9. This cycle of formulation was also based on only three broad comprehensive alternative potential plans of improvement. The details of this effort are presented in APPENDIX B.

THIRD FORMULATION CYCLE

The third formulation cycle resulted in a draft Maline Creek Survey Report dated March 1978. This report was designed to identify and provide all necessary detailed planning, hydrologic, and engineering detail that is conventional to careful and conservative Corps survey report analysis. The greater level of detail pursued in this formulation cycle resulted in the preparation of 137 alternative potential plans of improvements. The details of this extensive plan

of improvement search and screening are presented in APPENDIX B. In brief summary, the third formulation cycle was primarily important because the outdoor recreation and environmental quality planning work efforts accomplished during this cycle served as the basis for all formulation that followed, and for the plan of improvements eventually recommended herein. The intimate dependence of this study's formulation process upon outdoor recreation and environmental quality data, assessments, and impacts is apparent from the very outset. The preparation of separate environmental impact statements and data is an unnecessary duplicative publication process requirement in the case of this Maline Creek study because those concerns were the essential foundation of the entire study effort. The EIS documentation requirements are attached herein after identification of the recommended plan of improvements in order to serve as a useful recapitulation. The actual environmental planning, however, occurred throughout the plan formulation process. The economic optimization of flood control components pursued in the third cycle of formulation was critically reviewed and modified in the fourth cycle of formulation. This flood control optimization is summarized in APPENDIX B. The outdoor recreation and environmental quality planning are summarized in the following paragraphs because of their essential role in final plan formulation and selection of the recommended plan of improvements as mentioned earlier.

The third cycle first focused on the maximum possible realistic outdoor recreation and environmental quality opportunities as a means of establishing what could be accomplished if no other concerns were to be addressed. Concurrently and independently, work was focused on the flood control objective. The independent orientation of planning resulted in the development of three outdoor recreation plans called REC 4, REC 5, and REC 6, and five environmental plans called EQ 1 through EQ 5. The REC 6 and EQ 5

plans are the composites of their individual component planning efforts respectively. A summary of the composition of just the REC 6 and EQ 5 plans follows. The more detailed discussion of these plans is contained in APPENDIX B.

Outdoor Recreation Considerations

Field reconnaissance and judgment were used to prepare a practical and realistic gross maximization of the outdoor recreation opportunities of Maline Creek (REC 6 plan). The two major components of the REC 6 plan are a linear green belt strip park along the Maline Creek flood plain, and land acquisition/recreation development in upstream areas. This second feature coincides with, and then expands, the available open space locations which were concurrently and independently being considered as flood control detention site areas. The REC 6 plan consists of preserving open space at 16 potential detention site areas. Also included is a linear flood plain park connecting Bellefontaine County Park, Koeneman Park, Lange Royce Park, and Forestwood Park. The REC 6 plan also utilizes a 50-foot wide abandoned railroad right-of-way some 7.4 miles long (45 acres). The combined impact of both the railroad right-of-way plus the floodway area is to create an oval path of continuous visitor circulation and use, some 10 miles in length. An additional 3-mile extension would lead from this oval configuration to Endicott Park near St. Charles Rock Road. The performance of the outdoor recreation plan (REC 6) is shown in TABLE 4. It should be noted that during this third plan formulation cycle, the visitor-day attendance per activity and the value per visitor-day were based on conservative national and state averages appropriate at the time of analysis. Subsequently, revised updated criteria specific to the study area were used in the remaining plan formulation iterations leading to the selected plan of improvements.

Environmental Quality Considerations

The four major considerations leading to the development of the EQ 5 plan were: stream bank erosion; aquatic habitat diversity; terrestrial communities preservation; and litter/debris control.

Stream Bank Erosion. Significant stream bank stabilization needs were identified in 13 stream reaches plus five areas upstream of hydrologically modeled flood control stream reaches. Stream bank stabilization would be accomplished by using gabion bank treatment, or some similar type structures aesthetically pleasing in appearance. The benefits of this action would include the protection of property in the immediate vicinity, as well as improving the safety and aesthetic appearance of these eroded areas. No satisfactory means of identifying the tangible beneficial worth of stream bank stabilization was acceptable as described in the first two cycles of formulation.

Aquatic Habitat Diversity. Maximum aquatic habitat diversity opportunities were identified in both instream areas as well as in ponds. Instream fish pools are a means of increasing aquatic habitat diversity and could be created by constructing aquatic habitat structures. These fish pools would be located at approximately one quarter mile intervals in stream reaches having sufficient average annual flow. Another means of increasing the aquatic habitat is the construction of fish ponds. A maximum of 12 reasonable fish pond sites ranging in size from 1 to 6 acres was found suitable based on the following criteria:

a. Ponds should not be less than 1 acre in size with a drainage area to water surface ratio of at least 6 to 1, but not greater than 20 to 1.

TABLE 4
MALINE CREEK
MAXIMUM OUTDOOR RECREATION PLAN (REC 6)

ITEM	DETENTION ($1000)	LINEAR TRAIL ($1000)	TOTAL ($1000)
Summary of capital costs			
Detention sites/levee tracts	10,479	0	10,479
Flood plain trail	0	3,417	3,417
Railroad right-of-way	0	4,562	4,562
TOTAL CAPITAL COSTS	$10,479	$ 7,979	$18,458
Summary of average annual costs			
Interest and amortization*	694	529	1,223
Operation, maintenance, and replacements	53	39	92
TOTAL AVE. ANN. COSTS	$ 747	$ 568	$ 1,315
Summary of average annual benefits**			
Detention sites/large tracts	229	0	229
Flood plain trail	0	26	26
Railroad right-of-way	0	15	15
TOTAL AVE. ANN. BENEFITS	$ 229**	$ 41**	$ 270**

* Based on 6-5/8% interest rate, 100-year economic life. Subsequent plan cycles updated the interest rate to 7-1/8%.

** Based on visitation criteria per activity and visitor-day beneficial worth that was subsequently modified to reflect local conditions and updated values.

b. Ponds should have a maximum depth of 15 feet in about one-fourth of their area.

c. The pond site area should contain no unique wildlife habitat.

d. The ponds should be distributed throughout the watershed area.

e. More than 50 percent of the drainage area should be undeveloped if at all possible.

Terrestrial Communities Preservation. Maximization of terrestrial community opportunites identified two measures: land acquisition and wildlife management practices. The most effective way to address this need is to acquire and preserve those lands presently supporting significant terrestrial communities, including larger individual undeveloped tracts of land, as well as the undeveloped flood plain area. Eighteen such undeveloped areas were identified potentially available in 1978, totaling 1,369 acres. In addition to these individual sites, the undeveloped flood plain of Maline Creek could be acquired to provide a continuous undeveloped corridor between many of the undeveloped larger tracts. A total of 393 acres along 21 miles of Maline Creek were identified as the maximum possible corridor.

The wildlife management measure would involve activities on project lands as a stimulus to encourage local action on off-project lands. The on-project land work could be to develop the larger tracts and flood plain greenway for habitat enhancement. The off-project opportunity could focus on encouraging wildlife habitat development on residential lands. The following measures could be taken to encourage the development of wildlife habitat:

a. Provide technical assistance and plantings. The Missouri Department of Conservation is already developing a wildlife "bundle" of trees and shrubs for this urban area.

b. Establish wildlife demonstration areas on public lands. These areas would simulate typical backyard situations and show proper wildlife management practices. Each demonstration project would be maintained in the normal homeowner manner, such as trimming shrubs and mowing lawns.

c. Wildlife management seminars could be conducted and appropriate literature distributed.

d. A special program to encourage people to participate in backyard wildlife habitat enchancement could be conducted, with publicized contests for the greatest achievements.

Litter/Debris Control. Maximization of the opportunity to enhance the environmental quality by litter and debris control would focus on an initial intensive clean-up plus regular maintenance thereafter.

Flood Control Considerations

Formulating and analyzing alternative flood control strategies during the third formulation cycle were accomplished with the help of a rather sophisticated computerized Maline Creek hydro-economic model. This model was prepared and calibrated to be able to realistically display future flooding probabilities, both with various mixes of improvements and without those improvements. For computer analysis purposes, Maline Creek was subdivided into 33 stream and tributary formulation reaches plus the 15 individual detention sites. This approach provides the ability to examine a total of 48 interacting fundamental geographic sub-areas. In

addition, the hydro-economic model was able to simulate the hydro-economic impact of four types of channel improvement (earth, gabion, and two types of concrete improvement) in any of four different sizes each (extra small, small, medium, and large) along with any mix of four different detention site dam heights versus any of nine different low level outlet sizes.

In order to make useful and practical progress toward identifying the best flood control features, a screening process was developed. This screening process established various performance criteria as a means of reducing the very large number of potential alternatives to those that are realistic and most desirable.

A total of 122 single-purpose flood control plans was eventually tested, screened, and analyzed. The specific decisions reached regarding all 122 flood control plans are presented in APPENDIX B, and are not summarized here because the flood control formulation criteria were updated for the fourth (i.e., last) cycle of formulation. Six additional multi-purpose plans were also analyzed by the hydro-economic model, plus the three outdoor recreational plans and the five environmental quality plans, plus the draft best or "conventional" plan, bringing the total number of alternatives studied during the third cycle of formulation to 137.

The best plan from the array of 137 developed in the third cycle of formulation was termed the "conventional" plan primarily because its flood control performance was obtained via conventional flood control management measures (i.e., detention storage and channel improvements). No further discussion of the third cycle of formulation is pertinent to understanding the final decision process and is therefore presented only in APPENDIX B. The third cycle best plan was composed of conventional management measures and was carried through the entire analysis in order to insure the widest practical diversity and maximum flexibility in final decision making.

FOURTH FORMULATION CYCLE

Review and consideration of the March 1978 third cycle document resulted in the identification of additional, more stringent plan performance criteria. These "additional formulation criteria" are detailed in APPENDIX B. The impact of these additional criteria was to research, establish, and screen an additional 377 alternative potential plans of improvement. This comprehensive screening process is presented in APPENDIX B, and is summarized as follows:

The revised performance criteria, especially the goal to eliminate damage from the 10-year flood event in improved reaches, required that emphasis be first placed on least costly low level flood solutions. It was quickly obvious that low level flood protection was most effective in satisfying this added criterion. Detention and channel improvements were added to basic low level flood protection so as to improve flood control performance in a cost effective manner.

It was discovered that select, bridge removals and/or modifications when added to the other improvements yielded excellent flood control results. The best performing plans were then further screened on the basis of social well-being, regional development, and environmental effects. The details of this screening process are contained in APPENDIX B. Sixteen of the 377 plans passed the updated formulation criteria. It was clearly established that flood control at 100-year and/or higher frequency levels of protection could not be economically justified. A nominal 100-year plan called the "traditional" plan was created and tested, as described in APPENDIX B. Also tested was a completely nonstructural relocation plan, which further proved that greater levels of flood control were infeasible. The fourth formulation cycle was the basis for designating the group of 16 plans passing the updated screening

ASSESSMENT AND EVALUATION OF DETAILED PLANS

Sixteen plans were pursued in greater detail to serve as candidates for designation as the NED and EQ plans. An entirely nonstructural plan for removal of all 2,527 homes plus 56 recommended establishments out of the 100-year flood plain area was considered. Two of those plans were selected for the following detailed discussion to help the reader understand and focus attention upon the NED and EQ screening criteria.

NED PLAN

An NED plan was designated on the basis of which of the 16 plans plus nonstructural plan maximized net economic benefits. TABLE 5 presents a summary of the economic performance of the 16 plans considered viable out of all the plans studied. It may be observed that plan 78.3 produces the highest net benefits and is, therefore, the designated NED plan.

EQ PLAN

The designated EQ plan was identified as plan 78.2 on the basis of performance consisting of aquatic habitat structures to create instream pools, fish ponds, open space land acquisition, outdoor recreation development, and litter/debris control. TABLE 6 presents a summary of the environmental performance of the alternative plans. It may be observed that plans 78.2 and 78.3 perform equally well on the environmental testing display. Plan 78.2 was designated as the EQ plan in preference over plan 78.3 because of its better flood damage prevention on high frequency flood events. The details of this analysis are presented in APPENDIX B.

tests as candidates for NED and EQ designation. The nonstructural alternative consisting of basic relocation of flood damageable development was maintained as a possiole alternative to the very end of the decision process. Also carried through the entire process was the best cycle three "conventional" alternative plan, all done as a means of insuring the widest practical array of alternatives.

TABLE 5
NED PLAN FORMULATION
TOTAL AVERAGE ANNUAL BENEFITS AND COSTS: 7-1/8%
($1000)

Plan	Flood Control Benefits	Rec/EQ Benefits	Total Benefits	Flood Control Costs	Rec/EQ Costs	Total Costs	BCR	Net Benefits
50.6	$3,355	$ 937	$4,292	$2,505	$ 470	$2,975	1.44	$1,317
50.7	3,463	937	4,400	2,581	470	3,051	1.44	1,349
52.7	2,848	937	3,785	2,206	470	2,676	1.41	1,109
63.7	2,836	937	3,773	2,239	470	2,709	1.39	1,064
72.2	3,372	937	4,309	2,473	470	2,943	1.46	1,366
72.3	3,334	937	4,271	2,469	470	2,939	1.45	1,332
72.4	3,344	937	4,281	2,462	470	2,932	1.46	1,349
72.5	3,324	937	4,261	2,462	470	2,932	1.45	1,329
72.6	3,333	937	4,270	2,462	470	2,932	1.46	1,338
72.9	3,346	937	4,283	2,469	470	2,939	1.46	1,344
74.2	3,700	937	4,637	2,711	470	3,181	1.46	1,456
74.5	3,674	937	4,611	2,945	470	3,415	1.35	1,196
74.6	3,649	937	4,586	2,677	470	2,147	1.46	1,439
78.2	3,841	937	4,778	3,122	470	3,592	1.33	1,186
78.3	3,822	937	4,759	2,673	470	3,143	1.51	1,616
78.4	3,775	937	4,712	2,755	470	3,225	1.46	1,487
NS(1)	3,980	937	4,917	21,929	470	22,320	0.22	-17,403

(1) NS is the nonstructural 100-year flood plain relocation plan carried throughout the analysis.

(2) Subsequent refinements increased the REC/EQ beneficial effects via inclusion of fish ponds and aquatic habitat structures increasing benefits $1,059,000.

Shown below are the updated NED and EQ plans (78.3 and 78.2, respectively) from subsequent more detailed iterations.

78.2	3,753	1,059	4,812	2,997	577	3,574	1.35	1,238
78.3	3,704	1,059	4,763	2,889	435	3,324	1.43	1,439

TABLE 6
MALINE CREEK
ENVIRONMENTAL QUALITY PLANNING

	(1)	(2)	(3)			(4)	(5)	(6)
PLAN	Man-Made Resources	Natural Resources	Pollution Aspects Air	Water	Land	Animals and Plants	Ecosystems	Endangered Species
50.6	8	HEU	HAP	27	1	0	66	None
50.7	8	LEU	LAP	27	2	0	66	None
52.7	8	HEU	HAP	25	3	0	64	None
63.7	8	MEU	MAP	27	1	0	66	None
72.2	8	LEU	LAP	26	2	0	65	None
72.3	8	LEU	LAP	26	2	0	65	None
72.4	8	LEU	LAP	26	2	0	65	None
72.5	8	LEU	LAP	26	2	0	65	None
72.6	8	LEU	LAP	26	2	0	65	None
72.9	8	LEU	LAP	26	2	0	65	None
74.2	8	MEU	MAP	31	2	0	70	None
74.5	8	MEU	MAP	31	1	2	69	None
74.6	8	MEU	MAP	31	1	0	70	None
78.2	8	MEU	MAP	34	1	10	63	None
78.3	8	MEU	MAP	34	1	8	65	None
78.4	8	MEU	MAP	34	1	2	71	None
NS(1)	0	LEU	HAP	30	0	0	71	None

(1) Nonstructural 100-year flood plain relocation alternative.

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MITIGATION REQUIREMENTS

The potential need for mitigation of wildlife habitat destruction caused by the NED and EQ plans was evaluated by developing TABLE 7. First, the existing undeveloped wildlife habitat on project rights-of-way was determined. Then, the projected acreage of wildlife habitat with the "no project" and NED and EQ alternative plans was determined. Both the NED and EQ alternatives exceed the no project alternative by close to two-fold margins. Under both the NED and EQ alternatives, use of project lands would emphasize nature trails and similar outdoor recreation pursuits. Assurances from the local sponsors would require preservation of most of the habitat in its natural state. The conclusion from this analysis is that no wildlife habitat mitigation would be required for either the NED or EQ alternative plans.

The need for aquatic habitat mitigation was also considered. No mitigation would be necessary for the EQ plan, inasmuch as the plan includes both fish ponds and instream aquatic habitat structures to enhance the aquatic habitat beyond its currently degraded state. The decision as regards either attempting to preserve the cut-off reaches of stream in some aquatic habitat form or of including aquatic habitat structures in the improved reaches was deferred to post authorizaion studies. Neither alternative decision would result in cost changes sufficient to affect the final plan selection and is fundamentally dependent on what alternative plan, if any, is authorized..

"TRADITIONAL" PLAN

The minimum traditional level of flood protection for Corps participation in channel improvements in an urban area is 10-year

frequency. The creation and testing of a "traditional" flood control channel improvement plan, sized to prevent the 10-year frequency flood, was accomplished. The first cost of constructing this alternative was $148,000,000, with a 0.30 benefit-to-cost ratio. The details of this calculation are presented in APPENDIX B. The results of this test of a "traditional" plan clearly supported the recommended plan of improvements.

NONSTRUCTURAL PLAN

Relocation of all damageable structures within the 100-year flood plain area (i.e., 2,527 homes plus 56 commercial establishments) was found to be uneconomical, unimplementable and fundamentally undesirable. Another nonstructural alternative is to purchase in fee simple and relocate all damageable property in only the 10-year flood zone. To do so would require the purchase of 1,392 residential structures and 31 commercial establishments. The advantages to this somewhat more reasonable nonstructural alternative are as follows:

Major Advantages:

1. The structures would no longer be subject to damage.

2. Security to life, safety, and welfare would be improved.

3. Average annual damage (benefits) would fall by $3,477,600.

4. The annual savings of insurable costs, administrative costs, and flood fight costs would be $807,900.

The disadvantages of the scaled down nonstructural alternative are as follows:

1. Annual damages to zones of larger floods would continue.

2. Such a plan would have major social disruption.

3. The plan would cost $11,667,900 on an average annual basis.

4. The benefit-to-cost ratio is a very poor 0.07. That is, for every dollar invested in the nonstructural relocation approach only seven cents would be economically returned as benefits.

It is clear from an economic, regional development, and social well-being point of view that even the scaled down nonstructural alternative is undesirable and not worthy of further consideration. The details of these calculations are provided in APPENDIX B. This nonstructural test indicates that the recommended plan of improvements is better balanced and clearly more effective in addressing the flood control, environmental, and outdoor recreation needs.

"CONVENTIONAL" Plan

The best multi-objective plan defined in the three cycle of formulation consisted of conventioanl flood control management measures (i.e., detention sites and channel improvements). This "conventional" alternative plan was carried throught the final selection process even though its flood control damage reduction performance was only about 70 percent reduction effective, so as to insure the widest possible array of alternative choices.

TABLE 7
MALINE CREEK
MITIGATION ANALYSIS

Site	Project Acreage (A)	Current Undevel. Project Acreage	Projected Future Clearing			Net Acres Undeveloped Wildlife Habitat		
			No Project (B)	NED Plan (C)	EQ Plan (D)	No Project	NED Plan	EQ Plan
Detention Site								
MB2	14	14	14	0	0	0	14	14
MD1	20	0	0	0	0	0	0	0
MD1-1	73	73	60	8	10	13	65	63
MD2-2	41	41	31	6	10	10	35	31
MF1	35	35	0	5	5	35	30	30
MF2	6	0	0	0	0	0	0	0
MH1	70	70	70	12	14	0	58	56
M22	61	61	61	6	8	0	55	53
M27	64	64	64	11	15	0	53	49
Stream Corridor								
M1	18	6	6	4	4	0	2	2
M2	61	61	0	1	1	61	60	60
M3	18	18	0	1	1	18	17	17
M4	26	26	0	1	1	26	25	25
M5	59	59	0	5	5	59	54	54
M6	29	0	0	0	0	0	0	0
M7	24	0	0	0	0	0	0	0
M8	13	0	0	0	0	0	0	0
M9	47	10	0	4	7	10	6	3
M10	19	4	4	2	3	0	2	1
M11	6	0	0	0	0	0	0	0
M12	9	0	0	0	0	0	0	0
M13	16	4	4	2	2	0	2	2
M14	19	4	4	2	2	0	2	2
M15	12	0	0	0	0	0	0	0
M16	12	0	0	0	0	0	0	0
MB	3	0	0	0	0	0	0	0

TABLE 7 (Continued)
MALINE CREEK
MITIGATION ANALYSIS

Site	Project Acreage (A)	Current Undevel. Project Acreage	Projected Future Clearing: No Project (B)	Projected Future Clearing: NED Plan (C)	Projected Future Clearing: EQ Plan (D)	Net Acres Undeveloped Wildlife Habitat: No Project	Net Acres Undeveloped Wildlife Habitat: NED Plan	Net Acres Undeveloped Wildlife Habitat: EQ Plan
MD1	18	9	0	1	1	9	8	8
MD2	17	9	0	0	0	0	0	0
MD3	6	0	0	0	0	0	0	0
MD4	6	0	0	0	0	0	0	0
MD5	4	0	0	0	0	0	0	0
MD1-1	14	8	8	2	2	0	6	6
MD1-2	8	0	0	0	0	0	0	0
MH	10	0	0	0	0	0	0	0
Subtotal:								
Detention	384	358	300	48	62	58	310	296
Stream	474	209	26	25	29	183	184	180
Grand Total	858	567	326	73	91	241	494	476

A. This includes 567 acres for flood control plus 291 acres for EQ/Recreation (14 acres fish ponds plus 277 acres open space).

B. It is assumed that all of the lands in private ownership will be developed in the future without a project. Publicly owned lands will remain undeveloped.

C. The differences in clearing required for the NED and EQ plans are two-fold: (1) The NED plan requires no clearing for fishponds; (2) The NED plan requires no clearing for channel improvements in stream reaches M8 and M10.

D. This is a maximum value as it not only includes the complete clearing required for construction, but it includes selective clearing (brush-hogging of the understory, leaving the overstory trees).

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COMPARISON OF DETAILED PLANS

A comparison of primarily the NED and EQ "detailed" plans is next presented as an indication of the process used for identification of the recommended plan of improvements. Consideration was also given through final decision making to the "traditional" plan, a nonstructural plan and the "conventional" plan so as to insure the widest possible array of choices.

IMPACT ASSESSMENT

The environmental effects of the NED and EQ "detailed" plans were evaluated by comparing each plan's anticipated impacts against the future without-project condition. These effects are discussed in detail in APPENDIX B organized under the headings of physical, biological, and cultural impacts. In general, only significant impacts likely to influence the planning decisions are discussed. This includes a finding of no net impacts on certain resources that must be considered because of environmental policies or regulations. In very brief summary:

a. Regarding the physical elements of soils, water quality, and air quality, the EQ plan outperformed the NED plan. This occurred primarily because of the additional soil stabilization of the EQ plan provided by its aquatic habitat structures and fish ponds exhibiting a silt trap impact.

b. Regarding the biological elements of aquatic ecosystems, terrestrial ecosystems, and endangered and threatened species, the EQ plan clearly outperformed the NED plan due to the impact of the fish ponds and aquatic habitat structures.

c. Regarding the cultural elements of noise, displacements, housing, leisure, cohesion, growth, health, safety and welfare, tax revenue, property values, and land use, the NED and EQ plans performed about equally as well.

RATIONALE FOR DESIGNATION OF NED PLAN

Plan 78.3 was designated as the NED plan because it maximizes net tangible benefits the best of all 517 alternative plans studied.

RATIONALE FOR DESIGNATION OF EQ PLAN

Plan 78.2 was designated as the EQ plan because it maximized environmental performance the best of all 517 alternative plans studied. A summary assessment of the performance of EQ plan (i.e. 78.2) in fulfilling the EQ planning objective follows. The EQ objective was to address the flood problem and maintain and enhance the aesthetic and environmental qualities of the watershed. The EQ problems and needs fell into the following categories: stream bank erosion, water quality, aquatic habitat diversity, terrestrial communities, litter and debris, and noise. The degree to which each of these concerns would be addressed by the EQ plan 78.2 is discussed in the following paragraphs:

a. Stream bank erosion. Stream bank erosion is primarily a local problem and remains so outside the boundaries of the proposed plan. However, within the confines of the project area, most of the stream bank erosion problem areas would be stabilized under flood control plan 78.2 as a means of protecting the low level flood protectors.

b. Water quality. No measures were developed to specifically address this problem. As mentioned previously, the East-West Gateway Coordinating Council is developing plans to improve water

quality in the area. However, ancillary beneficial water quality benefits are expected from several features of plan 78.2, including protection from various stream pollutants because of construction of detention basins, fish ponds, grade control structures, and stream bank stabilization. Preservation of vegetation in detention basin sites and along the stream corridor would also reduce the entry of pollutants into the stream.

c. Aquatic habitat diversity. Diversity of habitat in the creek would be improved by the construction of plan 78.2 aquatic habitat structures in certain stream reaches, as well as by the construction of fish ponds at five detention sites. Construction of these structures would more than offset aquatic habitat damages resulting from channelization of environmentally sensitive stream reaches for flood control purposes.

d. Terrestrial communities. The need to preserve existing wildlife habitat has been addressed by plan 78.2 with its planned acquisition and preservation of undeveloped habitat lands along the stream corridor and at detention sites. The five fish ponds in plan 78.2, although not designed as measures to address the terrestrial communities' need, would enhance the detention areas as wildlife habitat.

e. Litter and Debris. An initial clean-up of project lands and annual maintenance of project lands are the features of plan 78.2 that address this need.

f. Noise. No measure has been developed to specifically address this need. Nevertheless, some noise benefits would accrue from plan 78.2 via its purchase and preservation of the 10-year flood plain. In many reaches along the stream corridor, the vegetation strip would be sufficient to reduce ground level noises to a nonintrusive level for persons using the trail.

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The EQ plan (i.e., 78.2) does not address any of these concerns to the absolute maximum extent possible, but it does make a significant contribution to each issue. The flood control component of the recommended plan (78.2) was also carefully screened to provide a maximum contribution to environmental quality. The designation of plan 78.2 as the EQ plan was done with the intent of providing a responsible, implementable level of environmental preservation and enhancement concurrent with practical mitigation of flood losses. All NED measures are located on, or adjacent to, lands that would be purchased for implementation of the flood control component.

RATIONALE FOR RECOMMENDED PLAN

Social well-being, regional development, and environmental quality considerations were used as decision criteria for plan formulation, screening and ultimate selection of the recommended plan. Each of these considerations is briefly summarized in the paragraphs below with a detailed presentation in APPENDIX B. Some of these screening criteria were relaxed in order to carry through to final decision making the nonstructural, "traditional" and "conventional" alternative plans. These three additional plans did not perform as well on all screening tests but were maintained in order to provide the widest possible array of alternative potential choices.

Social Well-Being Impact Analysis

During the screening process, 6 of the 14 social well-being variables were found to be useful in evaluating the alternatives. The following variables were of no use because they showed little or no variation in value:

Screening Variables Eliminated

Variable	Reason for Eliminating
(1) Noise levels	Small variance
(2) Aesthetic values	No judgments made
(3) Archaeological sites	No sites
(4) Historic sites	None on the National Register
(5) Transportation	No basis
(6) Education	No impact
(7) Cultural values	No impact
(8) Institution	No impact

The variables which were useful for making screening decisions are as follows:

Screening Variables Retained for Decision Making

(1) Homes displaced
(2) Housing values
(3) Leisure
(4) Cohesion
(5) Regional growth
(6) Health, safety, and welfare

Homes Displaced. As described earlier in the report, each alternative was evaluated in terms of the number of homes that would be displaced (purchased in fee simple) to prevent flood damages and for construction purposes. Displacement is both economically and socially injurious. It is intangibly injurious because a person or family suffers losses above and beyond those compensable under the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970; it is socially injurious when it involves dispersion and break-up of cultural units and neighborhoods.

In order to minimize this adverse impact, all plans which would displace 150 or more units were considered to display very poor social performance. It was felt that the purchase and resettlement of more than this number of units was overly adverse to the individuals and the general community stability. Most of the remaining plans would still require the resettlement of some housing units, but the number of units was less socially adverse.

Housing Values. The principles for rating housing values are discussed in APPENDIX H. All plans which made housing quality worse off were eliminated. Part of the purpose of flood control projects is to improve housing quality through flood damage mitigation. Plans which would fail to do this were not considered further.

Leisure Opportunity. Most of the alternative plans would contribute to easing the park deficiency problems through the development of dry detentions. The greatest shortages are in neighborhood and district parks which account for an average of 75 percent in expected deficiencies over time. Any plan which utilizes at least 7 detention sites would relieve these deficiences by the addition of 266 acres. To screen alternatives, any plan which did not use at least seven detention sites was eliminated. Some flood control plans used no detention sites and a few used 15 detentions. The average number was eight. A successful plan would have to contribute to the elimination of park acreage deficiencies, relieve park carrying capacity problems, and increase recreation opportunity.

Community Cohesion. As discussed earlier, community cohesion was based upon the degree of flood damage reduction. Plans which would not reduce annual flood damages by at least 75 percent were eliminated. As mentioned earlier, an exception was allowed for the "traditional" nonstructural and "conventional" alternative plans in order to display the wide diversity of alternative potential solutions studied.

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Regional Growth. Alternatives which demonstrated a low growth potential were screened out. An alternative which had moderate to high growth potential would help reduce unemployment and underemployment problems and thus be a desirable alternative plan.

Health, Safety, and Welfare. This parameter was quantified by the percent damage remaining after a 100-year frequency event. It was felt that any plan which would not eliminate at least 50 percent of the damages of this event was unsatisfactory. This flood damage mitigation constraint is somewhat arbitrary but served to eliminate those plans which would not substantially contribute to the improvement of community health, safety and welfare. A 50 percent reduction of 100-year event damages makes substantial contributions in reducing catastrophic losses.

In total, the screening process summarized above aided in eliminating plans which performed poorly from a social well-being perspective. Some plans failed each and every constraint and criteria listed above. Most plans failed in at least three of the constraints. Only 21 percent of the 377 plans passed this screening. The designated EQ and NED plans passed all social well-being constraints. As mentioned previously, the "traditional," nonstructural and "conventional" alternative plans were carried forward even though they did not pass all the social well-being tests, simply to display the comprehensive diversity of the search for a recommended plan of improvements.

Regional Development Screening

APPENDIX B presents the variables used in regional development screening. Only one of the variables - Displaced Farms - was not useful in screening. All other variables showed enough variability to be useful in screening. Once again, the "traditional,"

nonstructural and "conventional" alternative plans did not pass all regional development screening criteria, but were carried through to provide the widest possible diversity of alternative choice.

Tax Revenue. Most local and regional governments throughout the nation are experiencing a fiscal crisis due to voter concern about tax increases. Social services and facilities are still required and must be paid for. This situation is severe enough that any solution proposed for Maline Creek should significantly contribute in assisting local governments in their abilities to raise revenue. The average tax revenue that is generated by the 377 cycle four plans is $770,000. Any plan which does not contribute at least this amount of tax revenue was screened out.

Property Values. It is known locally that the difference in value of homes located on the flood plain and those off the flood plain in Maline Creek is $1,800. The average contribution made by any of the 377 plans to the capturing of this difference was $1,500. Plans which did not capture at least this amount were eliminated.

Public Facilities/Public Services. The measure of public facilities and services was the number of dry detention sites proposed by each plan. With each detention site there are associated trails, parks, nature walks, and bicycling services and facilities. As discussed earlier, these facilities and services have a recreation and flood control component and at least seven dry detentions would be needed to relieve the park acreage deficiencies. Alternatives containing less than seven detention sites did not perform well in easing public facilities/service problems and shortages.

Man-Years of Employment. The unemployment rate for the St. Louis Standard Metropolitan Statistical Area (SMSA) is 5.2 percent. Plans contributing the most to eliminating this problem were retained

The greatest contributions would be made by contributing 1,533 man-years of work. All other plans were screened out.

Business Activities. Business growth and sales activity are important to the welfare of any urban area. Business activities are primarily impacted by state and local taxes, employment, and personal income. With the multiplier effects, the best plans would create sales of $77,200,000. Alternatives that would generate less sales activity were screened out.

As before, the screening criteria established during this analysis eliminated plans not contributing to regional development or were weak in positive contributions. Fifty-five percent of the 377 plans remained - forty-five percent performed poorly and were eliminated. The EQ plan and NED plan passed all criteria.

Environmental Quality Planning

APPENDIX B identifies the data used for environmental screening. Since there are no endangered or threatened species in the Maline Creek Basin, this variable did not contribute to the screening process.

Man-Made Resources. The criteria used to screen plans based on public facilities and public services were also used to evaluate man-made resources. The principal thrust was recreation and flood control. Plans that would not lead to the development of at least seven dry detention sites would not contribute enough to the development of man-made resources and were eliminated. Seven detention sites would be the minimum required to meet needs.

Natural Resources. The national energy crisis prompted the screening out of all high energy use plans. Alternatives that would

consume moderate-to-low energy resource inputs during construction were retained. This also aided in eliminating plans which would consume large quantities of other natural resources.

Air Pollution. Because of national policies such as the Clean Air Act, alternatives that would not promote high air pollution were dropped. These are also the same plans which would use greater quantities of energy and other natural resource inputs.

Water Pollution. Public Law 92-500 establishes the policy, goals, and objectives of national importance to water use. As shown in APPENDIX B, each plan was evaluated in terms of its contribution to meeting the mandates of PL 92-500. The maximum number of improved reaches of any alternative was 40. Alternatives that would not capture at least 75 percent of these reaches were screened out. The 75 percent figure is arbitrary but eliminated plans not contributing significantly to PL 92-500.

Land Pollution. As discussed earlier in the report, some plans utilized large walls and levees which were thought to contribute to significant man-made land pollution.

Animal and Plant. The numbers used to evaluate a plan's impact on animal and plant habitat indicate the degree of high-grade habitat destroyed by construction activities as described in detail in APPENDIX B.

Ecosystems. Ecosystem rankings are a combined assessment of water pollution and animal and plant destruction as described in detail in APPENDIX B.

The total impact of this screening process was severe. Only 7 percent of the 377 plans passed the criteria. The EQ plan and NED

plan were among the remaining alternatives. The "traditional" nonstructural and "conventional" alternative plans were again carried through to provide the widest possible diversity of alternative choice.

DRAFT RECOMMENDED PLAN

Examining all screening criteria and all plans, only two plans or one-half of one percent of the 377 plans passed all tests. Plans 78.2 and 78.3 meet all screening criteria as shown in TABLE 8.

The EQ plan (78.2) is selected as the draft recommended plan.

PLATE 2 summarizes the flood control features of the draft recommended plan with a detailed presentation in APPENDIX E. PLATE 3 summarizes the recreation and environmental quality features of the draft recommended plan with a detailed presentation in APPENDIX F. The reason 78.2 was selected over 78.3 is illustrated in TABLE 9. Part A of TABLE 9 shows the differences in damages remaining at each flood event for the entire basin. Plan 78.2 carries with it less risk at greater flood event than does plan 78.3. Part B of TABLE 9 shows the same data but for modified reaches only. It is clear from a risk analysis that plan 78.2 provides greater damage reductions - especially with larger floods for the entire basin and modified reaches.

Draft Recommended Plan Without Low Level Levee and Floodwalls

The flood control performance of the recommended plan of improvements without use of low level structures is poor and does not provide positive 10-year protection. Details of this calculation are presented in APPENDIX B.

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TABLE 8
MALINE CREEK
FINAL DECISION CRITERIA

Plan	Plans Passing F.C. Screening: Min 10-Yr. Protection	Min. 1.20 BCR	$1000 or Less Induced Dem.	Plans Passing: SWB Screening	RD Screening	EQ Screening	Plans Possessing All Criteria
50.6	Yes	Yes	Yes	Yes	Yes	No	-
50.7	Yes	Yes	Yes	No	Yes	No	-
52.7	Yes	Yes	Yes	No	No	No	-
68.7	Yes	Yes	Yes	No	No	No	-
72.2	Yes	Yes	Yes	No	No	No	-
72.3	Yes	Yes	Yes	No	No	No	-
72.4	Yes	Yes	Yes	No	No	No	-
72.5	Yes	Yes	Yes	No	No	No	-
72.6	Yes	Yes	Yes	No	No	No	-
72.9	Yes	Yes	Yes	No	No	No	-
74.2	Yes	Yes	Yes	No	No	Yes	-
74.5	Yes	Yes	Yes	No	No	Yes	-
74.6	Yes	Yes	Yes	No	No	Yes	-
78.2	Yes	Yes	Yes	Yes	Yes	Yes	78.2
78.3	Yes	Yes	Yes	Yes	Yes	Yes	78.3
78.4	Yes	Yes	Yes	No	Yes	Yes	-
NS(1)	Yes	No	Yes	No	Yes	Yes	-

(1) Nonstructural 100-year flood plain relocation plan.

TABLE 9
MALINE CREEK
EVENT ZONAL DAMAGES REMAINING ($1000)

Plan	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	500 yr
				Flood Event in Years of Return Interval			
				A. Entire Basins			
78.2	$12	$53	$134	$1,401	$4,803	$ 9,988	$33,149
78.3	12	53	134	1,615	5,440	10,505	33,794
Diff.	$ 0	$ 0	$ 0	$- 214	$- 637	$- 517	$- 645
				B. Modified Reach			
78.2	$ 0	$ 0	$ 0	$1,106	$4,377	$ 8,682	$30,232
78.3	0	0	0	1,319	5,013	9,199	30,878
Diff.	$ 0	$ 0	$ 0	$- 213	$- 636	$- 517	$- 646

It can be observed that this test clearly proves that low level flood protection is a very effective flood control management measure for: a. extending protection to a minimum 10-year flood event; and b. providing a significant reduction in average annual flood damages. This test shows that low level flood protection is effective and efficient and is therefore a very worthwhile aspect of the recommended plan of improvements.

Draft Recommended Plan Degree of Flood Protection

The purpose of this section of the report is to analyze the concept of degree of flood protection as it applies to Maline Creek recommended plan. Degree of protection has often been used to measure the relative performance of alternative plans. It is the minimum level of protection provided by a flood control measure at the particular location. Structural flood control measures are designed to control flood waters - they deal with the flood, not directly with the structures they protect. Because of this

performance characteristic, a uniform level of protection is traditionally and physically possible. For example, a levee prevents a particular flood event and does so for all structures within the flood plain of that particular event. It is more difficult to provide uniform flood protection with most nonstructural measures because most of these measures are individualistic and site specific. In addition, nonstructural plans are likely to use a mix of flood mitigation measures. Each measure performs differently. As in the case of Maline Creek, the recommended plan protects each reach (or section within each reach) at different levels making uniform protection unlikely. For this reason, degree of protection as a traditional indication of performance does not reveal the real effectiveness of the plan. This does not imply that degree of protection should be disregarded, but the effectiveness might be better displayed as the degree of average annual damage reduction. In actuality, it is the concepts developed for nonstructural solutions which have been extensively used in formulating an efficient and effective recommended plan for Maline Creek.

During the fourth (i.e., last) formulation cycle, each of the 377 plans focused on resolving the numerous specified constraints, problems, and criteria. It was discovered that a mix of structural and nonstructural measures performed best. This approach resulted in a 90 percent damage reduction. The degree of protection varied by reach and no doubt within each reach. Uniformity was not possible, however, in analysis of the EQ plan it was found that all protected reaches received at least a complete 10-year frequency level of protection. These levels of flood protection are summarized below:

Level of Protection (years)	Number of Reaches	Level of Protection in Percent Probability
2	4 (unprotected)	Less than 50
2	1 (unprotected)	About 50
5	1 (unprotected)	20
10	19 protected	10
25	5 protected	4
50	1 protected	2
100	1 protected	1
SPF	1 protected	Less than 1

The question might arise - why not greater levels of protection? There are three reasons for this. They include the following:

a. Greater wall/levee heights may create a safety hazard.

b. Nominal 100-year protection is too costly (B/C = 0.36 to 1.00).

c. Larger channels and floodwalls/levees were tried and lacked economical justification.

Each of these reasons is further discussed in the following paragraphs.

One argument for not providing higher levels of protection by structural means, such as levees, is that of creating a catastrophe. Measures employing the low level walls/levees were limited to 3-foot maximum height. Greater heights than 3 feet were felt to possibly create a safety trap from floods of greater magnitude. Heights ranging from 1 to 3 feet are low level and would not create a safety trap. Flood waters surpassing a 1-, 2- or 3-foot levee should create a manageable and noncatastrophic type situation. Another spin-off advantage of low levees/walls is that they would tend to inhibit future development. Their visable presence serves as a constant reminder of the potential threat of

flood damages. This being the case, there would probably be less future induced damage with the levees/walls in place and highly visable, than with no visable protection at all. Higher levees/walls would create the opposite behavior. For example, a 6- or 8-foot wall designed to protect against say a 50-year flood may create a false sense of security and thereby induce greater future development. If a 100-year event were to occur under these circumstances, a catastrophe might result. By constraining levee/wall heights to a maximum of 3 feet, a false sense of security is avoided.

Another primary reason for not providing greater levels of protection lies in overwhelming costs. A 100-year level of protection was tested for both structural and nonstructural techniques. Cost estimates indicated that either technique would cost much more than its benefits. These costs did not include home relocations with attendant social disruption. Clearly, a 100-year or greater level of protection could not be economically constructed by structural means, and relocating 2,527 families plus 56 commercial establishments makes the nonstructural relocation alternative very costly.

The third and final reason for not providing greater degrees of protection is found in implementability. It has been indicated that greater levee/wall heights can create a safety trap, and that higher levels of protection are economically unacceptable. These problems are overcome by the total relocation alternative, but moving 2,527 families plus 56 commercial establishments is not realistically implementable. The recommended plan has a sound BCR, is sensitive to environmental concerns, includes recreation components and is implementable. Also studied was a "traditional" plan, a nonstructural plan and a "conventional" alternative plan each of which provided less than 90 percent damage reduction. Those additional plans were carried forward in order to identify the widest possible array of alternative choices.

VIEWS OF NON-FEDERAL INTERESTS

Statements or resolutions indicating the views and recommendations of non-Federal interests will summarized here, and documented in APPENDIX C.

REVIEW BY OTHER FEDERAL AGENCIES

Planning for flood control and allied Maline Creek improvements has been coordinated with many Federal agencies. Special thanks for the assistance rendered by the following Federal agencies is warranted:

Department of Housing and Urban Development
Environmental Protection Agency
Federal Emergency Planning Agency
Fish and Wildlife Service
Heritage Conservation and Recreation Service
Soil Conservation Service
United States Geological Service

Letters received from all agencies expressing their views and recommendations are contained in APPENDIX C. Basically, all agencies reviewing this report have indicated concurrence with the recommended plan.

RECOMMENDED PLAN

The recommended plan of improvements is the EQ plan previously identified as plan 78.2. All documents and information pertaining to the proposed Maline Creek project, as well as the documented views of other interested agencies and the concerned public, have been reviewed and evaluated in the total public interest, relative to the various practical alternatives for meeting the water and related land resources needs of the Maline Creek watershed.

The possible consequences of the proposed action have been studied in accordance with environmental, social well-being, and economic effects as well as engineering feasibility. In evaluation, the following points were considered pertinent:

1. Environmental Considerations. Reasonable steps have been taken to assemble and present the known environmental consequences of the proposed action. The present environmental character of Maline Creek varies from semi-natural to severly altered. Future conditions are expected to result in a totally altered, urban storm drainage system. Therefore, the recognized disruption of terrestrial plant and animal communities and the reduced aquatic biological productivity that would be unavoidable during project construction appear to be more than offset by the improved aesthetic and amenity values the recommended plan generates from both the humar perspective as well as the fish and wildlife perspective.

2. Social Well-Being Considerations. Flood protection provided by the recommended plan would directly enhance the general economic welfare and security of the people by reducing property and structure damages and the threat to health and loss of life. Also improved would be some of the intangible human suffering caused by

flood events and attendant loss of employment, post-flood cleanup work, and the concern expressed in anticipation of flood events. The outdoor recreational and environmental quality opportunities presently available for the Maline Creek watershed offer a rare opportunity to significantly improve a broad array of social well-being considerations. The opportunity to prevent continued population and human habitation crowding within this watershed would be significantly improved by the preservation and wise use of the limited remaining flood plain open space.

3. Engineering Feasibility. From an engineering standpoint, flood protection would not be maximized because of the adverse impact this action would have on the environment and social well-being. However, the recommended plan does provide a significant degree of flood damage reduction.

4. Economic Considerations. From an economic standpoint, the recommended plan is not the optimum solution. However, the plan is economically justified and deviates from the economic optimum in a manner fully warranted by environmental quality and social well-being considerations. The selected plan has a benefit-to-cost ratio of 1.35 as compared to 1.43 for the NED plan.

5. Summary Display of Beneficial and Adverse Effects. Major beneficial and adverse effects of the plan of improvements recommended for Maline Creek (EQ plan), as well as the effects of the NED and no action plans, are displayed in TABLE 10.

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TABLE 10
MALINE CREEK
SUMMARY OF MAJOR BENEFICIAL AND ADVERSE EFFECTS

	NO PROJECT ALTERNATIVE (WITHOUT CONDITION)	NED PLAN 78.3	EQ PLAN 78.2 (SELECTED PLAN)
1. PLAN DATA			
Flood Control Components	No major structural improvements	2.22 miles of channel widening and straightening; 8 Detention Basins; 10.89 miles of floodwalls; 6.68 miles of earth levees; 73 acres of clearing; 21 bridge modifications	3.29 miles of channel widening and straightening; 8 Detention Basins; 5.05 miles of floodwalls; 3.31 miles of earth levees; 91 acres of clearing; 5 bridge replacements; 2 bridge improvements
Other Components	Flood plain regulations; participation in, and compliance with National Flood Insurance Program	Flood plain regulations; participation in, and compliance with National Flood Insurance Program plus no aquatic habitat structures or fish ponds and 384 acres open space acquisition adjacent to the detention basins plus 474 acres along the stream corridor.	Flood plain regulations; participation in, and compliance with National Flood Insurance Program plus 18 aquatic habitat structures, 5 fish ponds, 384 acres open space acquisition adjacent to the detention basins plus 474 acres along the stream corridor, 10 miles of trails.
2. NATIONAL ECONOMIC DEVELOPMENT			
Beneficial Effects	Without improvement no beneficial reduction in flood damages can be anticipated. Future conditions without improvements, flood damages to existing properties is estimated to be on the average of $4,145,000 annually	$3,704,000 average annual flood damage reduction; $1,059,000 average annual recreation benefits;	$3,753,000 average annual flood damage reduction; $1,059,000 average annual recreation benefits;

TABLE 10 (Continued)
MALINE CREEK
SUMMARY OF MAJOR BENEFICIAL AND ADVERSE EFFECTS

	NO PROJECT ALTERNATIVE (WITHOUT CONDITION)	NED PLAN 78.3	EQ PLAN 78.2 (SELECTED PLAN)
Adverse Effects	Continuation of damages, relocation costs, flood insurance administration costs - $4.145 million average annual damages	$3,324,000 average annual costs;	$3,574,000 average annual costs;
Net Effects	Negative, Not Quantified	$4,763,000 benefits/ $3,324,000 costs/1.43 BCR	$4,812,000 benefits/ $3,574,000 costs/1.35 BCR
3. ENVIRONMENTAL QUALITY			
Beneficial Effects	Insignificant	Erosion control, mitigation, and corridor preservation acreage; and recreational development	Erosion control, habitat diversity, and improvement, mitigation acreage, park acreage, and corridor acreage; wildlife management of public lands and recreational development
Adverse Effects	Degradation and destruction due to urbanization, flooding, and erosion, Not Quantified	Pollution, disruption, siltation, channel shortening, and habitat destruction due to project construction; urbanization	Pollution, disruption, siltation, channel shortening, and habitat destruction due to project construction; urbanization
Net Effects	Adverse, Not Quantified	Not Quantifiable	Positive, Not Quantifiable

TABLE 10 (Continued)
MALINE CREEK
SUMMARY OF MAJOR BENEFICIAL AND ADVERSE EFFECTS

	NO PROJECT ALTERNATIVE (WITHOUT CONDITION)	NED PLAN 78.3	EQ PLAN 78.2 (SELECTED PLAN)
4. SOCIAL WELL-BEING			
Beneficial Effects	Gradually reduces susceptability to flooding	Flood protection, recreational and aesthetic improvements, and increased incomes due to employment	Flood protection, recreational and aesthetic improvements, and increased incomes due to employment
Adverse Effects	Community and individual disruption due to relocation and flooding	Temporary inconveniences during construction and relocations plus recreational areas considered hazard or nuisance impacts by some.	Temporary inconveniences during construction and relocations plus recreational and habitat areas considered hazard/nuisance by some
Net Effects	Adverse	Positive, Not Quantified	Positive, Not Quantified
5. REGIONAL DEVELOPMENT			
Beneficial Effects	Insignificant	Insignificant	Insignificant
Adverse Effects	Insignificant	Insignificant	Insignificant
Net Effects	Insignificant	Insignificant	Insignificant

6. Conclusion. It is concluded that the proposed action is based on a thorough analysis and evaluation of many alternative courses of action for achieving the stated objectives; that whenever adverse effects are found to exist, they were avoided by following reasonable alternative courses of action which would also achieve the specified objectives; that where the proposed action has an adverse effect, this effect either is ameliorated or substantially outweighed by other considerations; that the proposed action is consonant with national policy, statutes, and administrative directives; and that, on balance, the total public interest will best be served by the implementation of the recommended EQ 78.2 plan of improvements.

IMPLEMENTATION RESPONSIBILITIES FOR SELECTED PLAN

Federal statutes and regulatory precedent have established the traditional basis for Federal and non-Federal responsibilities in the construction and operation and maintenance of Federal water projects. The traditional division of responsibilities is based on the resulting policy governing flood control works and associated recreation development at non-reservoir projects. The traditional cost sharing requirements are presented in TABLE 11 but are not recommended for implementation. This is because President Carter, in his 6 June 1978 message to Congress on water policy, proposed cost sharing reforms which impact the Maline Creek recommendations. The Corps of Engineers is required to recommend cost sharing in accordance with President Carter's proposal as shown in TABLE 12. A summary of benefits and costs for the recommended plan (7-1/8 percent interest rate) is shown in TABLE 12A. The allocation of operation and maintenance costs remains entirely a non-Federal responsibility under either traditional or President Carter's proposal, as shown in TABLE 13. In addition to cost sharing requirements, specific non-Federal requirements are set forth in the "Recommendations" section of this report.

TABLE 11
MALINE CREEK
TRADITIONAL CONSTRUCTION COST APPORTIONMENT
(NOT RECOMMENDED)

ITEM	FEDERAL	NON-FEDERAL	TOTAL
01. LANDS AND DAMAGES	$ 840,000	$ 10,300,000	$ 11,140,000
02. RELOCATIONS	0	2,720,000	2,720,000
04. DAMS	6,170,000	0	6,170,000
06. FISH AND WILDLIFE	880,000	290,000	1,170,000
09. CHANNELS AND CANALS	5,570,000	0	5,570,000
11. LEVEES AND FLOODWALLS	8,850,000	0	8,850,000
14. RECREATION	1,400,000	1,400,000	2,800,000
30. ENGINEERING AND DESIGN	2,750,000	580,000	3,330,000
31. SUPERVISION AND ADMINISTRATION	1,680,000	370,000	2,050,000
TOTAL CONSTRUCTION COSTS	$ 28,140,000	$ 15,660,000	$ 43,800,000

TABLE 12
MALINE CREEK
PRESIDENT CARTER'S PROPOSED CONSTRUCTION COST APPORTIONMENT

ITEM	STATE COST	NON-FED COST	FED COST	TOTAL COST
Flood Control	$1,890,000	$ 7,550,000	$28,300,000	$37,740,000
Recreation	230,000	2,330,000	2,100,000	4,660,000
Environmental Quality	70,000	700,000	630,000	1,400,000
TOTAL CONSTRUCTION COSTS	$2,190,000	$10,580,000	$31,030,000	$43,800,000

TABLE 12A
MALINE CREEK
SUMMARY OF BENEFITS & COSTS FOR THE RECOMMENDED PLAN
7-1/8%

Benefit Category	Average Annual Benefits	Average Annual Costs	BCR	Net Benefits
Flood Control	$3,753,000	$2,997,000 1/	1.25	$ 756,000
Recreation/EQ	1,059,000	577,000 2/	1.84	482,000
TOTALS	$4,812,000	$3,574,000	1.35	$1,238,000

1/ Includes $306,000 flood control share of O&M costs.

2/ Includes $144,000 rec/EQ share of O&M costs.

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TABLE 13
MALINE CREEK
O&M COSTS (ENTIRELY NON-FEDERAL)

ITEM	COST	PROJECT PURPOSE
Detention Sites (exluding recreation)	$ 58,900	Flood Control
Channel Improvements	74,700	Flood Control
Grade Control Structures	11,000	Flood Control
Stream Bank Stabilization	17,600	Flood Control
Selective Clearing	3,700	Flood Control
Levees and Floodwalls	64,000	Flood Control
Interior Drainage System	45,000	Flood Control
Sewer Modifications	4,200	Flood Control
Bridges	26,500	Flood Control
(Subtotal Flood Control)	($ 305,600)	
Fish Ponds	24,800	Environmental Quality
Aquatic Habitat Structures	17,000	Environmental Quality
(Subtotal Environmental Quality)	($ 41,800)	
Recreation	102,600	Recreation
(Subtotal Recreation)	($ 102,600)	
TOTAL O&M COSTS	$ 450,000	

REMAINING WORK AND TIME SCHEDULE

The following actions are necessary to begin construction of the proposed Maline Creek project:

1. Review and approval of this report by the Corps of Engineers, Lower Mississippi Valley Division; the Board of Engineers for Rivers and Harbors; and the Office, Chief of Engineers. The Chief of Engineers may then seek formal review and comment by the Governor of Missouri and interested Federal agencies.

2. Following state and interagency formal review, the final report of the Office, Chief of Engineers can be forwarded by the Secretary of the Army to the Congress, subsequent to the Secretary of the Army seeking the comments of the Office of Management and Budget regarding the relationship of this project to the program of the President.

3. Congressional authorization of the proposed project would then be required. This would include all appropriate review and hearings by the Public Works Committees. If the project were to be authorized by the Congress either for construction or for Phase I design only, the Chief of Engineers would then include funds, when deemed appropriate, in his budget request for the design and construction of the Maline Creek project.

4. Advanced engineering and design studies would be initiated upon receipt of appropriate authority and funding to proceed and necessary funds. The Maline Creek project formulation would be carefully reviewed and refined at that time, and the plan of improvements reaffirmed or modified as necessary to meet the prevailing conditions. The local sponsor and the state of Missouri would then be required to furnish a letter of intent to the Corps of Engineers regarding the specific local cooperation requirements.

5. Surveys, materials investigations, and preparation of design criteria, detailed plans, specifications, and an engineering estimate of costs would then be accomplished by the Corps of Engineers. At the completion of Phase II design, plans and specifications would then be prepared, bids would be invited, and a contract awarded. Prior to construction, formal assurances would be required from the local sponsor and state of Missouri and the necessary local actions required would have to be completed.

6. Following completion of project construction, or any separable units thereof, local interests would be responsible for appropriate operation and maintenance.

It is very difficult to accurately estimate a time schedule for all the steps listed above because of the many variables in the reviewing and funding processes. However, for generalized purposes of analysis, a Maline Creek project completion date in 1991 is theoretically possible if there are no undue delays. It should be noted that a final environmental impact statement would accompany the final report of the Chief of Engineers and that the final environmental impact statement would be supplemented or revised, as appropriate, during post-authorization studies prior to construction.

ENVIRONMENTAL IMPACT STATEMENT

Regulatory requirements cause an awkward publication problem due to the need to present the environmental impact statement (EIS) information as a separable report segment, yet contain that separate report within this main report. The basic environmental concerns have been an integral part of plan formulation from the outset as amply demonstrated by selection of the EQ plan as the recommended plan. Thus, the report "separation" of the EIS in no way insinuates a separation or lack of environmental plan formulation involvement. Locating the EIS "separate" from the main report (i.e., attached at the end) has been done so that the EIS may serve the reader as a review or recapitulation of the Maline Creek plan formulation process.

A cultural resources survey has been completed within the Maline Creek watershed. One site on the National Register of Historic Places, the Bissel House, is located in the watershed but not within the project boundaries. Extensive urbanization has destroyed all but an insignificant portion of the archaeological record within the watershed. No significant impacts on historic or archaeological sites is expected from project implementation.

A preliminary Section 404(b)(1) evaluation (Clean Water Act, Public Law 92-500) has been completed for Maline Creek. This evaluation is included as APPENDIX J of this Survey Report.

Based on studies and investigations at this stage of design, the proposed action is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of critical habitat of such species.

CONCLUSIONS

This study was undertaken to determine the advisability of installing improvements in the interest of water and related land resource problems and opportunities in the Maline Creek watershed, Missouri. Serious flood and flood-related problems do exist in this highly urbanized watershed and its flood plain area. The opportunity to satisfy unmet outdoor recreational needs and significantly improve the future fish and wildlife habitat all combine very favorably with the flood control solution to provide a naturally oriented and aesthetically appealing urban improvement.

While not required as part of the Maline Creek recommended plan of improvements, local interests should give serious attention and consideration to capturing the advantages of the abandoned railroad right-of-way as a supplemental open space greenbelt corridor. Appropriate acquisition and development of this railroad right-of-way would provide the opportunity for an oval shaped hiking/nature trail configuration enhancing ease of circulation and improving access to the adjacent park areas. This non-project feature is considered to be worthy of major local benefit and is recommended for high priority local action.

In formulating plans to meet the flood control, outdoor recreation, and environmental quality objectives, all alternatives showing any potential for satisfying the needs were examined. Screening of unfavorable alternatives was accomplished through progressive comparisons of the alternatives, with full consideration given to the economic, social, and environmental performance of each alternative. The relative merits and shortcomings of each alternative were explored. Entirely nonstructural alternative solutions were considered and found to be not only economically very poor performing alternatives, but to be notably socially disruptive.

The recommended plan of improvements for Maline Creek consists of a combination of channel modifications, detention basins, low levees, low floodwalls, bridge modifications and replacements, fish ponds, aquatic habitat structures, open space acquisition, and litter/debris control. These improvements provide only partial flood protection to the property and structures in the Maline Creek flood plain. Significant average annual flood damages remain even after installation of the recommended plan. To maintain and possibly expand the effectiveness of this project, local interests are encouraged to adopt flood plain regulations for all areas below the modified 100-year flood elevation, in accordance with the National Flood Insurance Program.

President Carter, in his June 1978 water policy message to Congress, proposed several changes in cost sharing for water resource projects such as Maline Creek to allow states to participate more actively in project implementation decisions, and to equalize cost sharing between structural and nonstructural flood damage prevention projects. These changes impact the Maline Creek recommended cost sharing as shown herein

The estimated capital cost for the recommended project is $43,800,000 (October 1979 price level), of which $31,030,000 would be Federal, $10,580,000 local sponsor, and $2,190,000 would be the responsibility of the state of Missouri. Average annual charges (including $450,000 major replacements and operation and maintenance) amount to $3,574,000. Total average annual benefits are estimated to be $4,812,000 (with redevelopment benefits) yielding a benefit-to-cost ratio of 1.35 to 1.

The proposed Maline Creek improvements are needed immediately to serve the existing and foreseeable water and related land resources needs of this urban area. This project was selected as the best

means to serve the flood control, outdoor recreation, and environmental quality needs in a well balanced manner. Full consideration was given to the environmental, social well-being, and economic effects as well as the engineering feasibility of all apparent alternatives.

RECOMMENDATIONS

It is recommended that the EQ plan of improvements (i.e., plan 78.2) for Maline Creek, generally as formulated in this report and shown, PLATES 2, 3 and 4, be authorized for construction at an estimated total capital cost of $43,800,000 (October 1979 price level), with an estimated annual operation, maintenance and replacement cost of $450,000 (October 1979 price level), all in accordance with plans contained in this report and subject to such modifications as the Chief of Engineers may deem advisable, and subject also to the provision that unless otherwise stated in these recommendations, the exact amount of non-Federal contributions shall be determined by the Chief of Engineers prior to project construction, generally in accordance with the following local cooperation requirements:

1. Prior to construction, the state of Missouri will furnish 5 percent of the first cost of construction allocated to flood control, currently estimated to be $1,890,000 cash or in-kind contribution;

2. Prior to construction, non-Federal interests will furnish 20 percent of the first cost of construction allocated to flood control, currently estimated to be $7,550,000 cash or in-kind contribution;

3. Prior to construction, the state of Missouri will furnish 5 percent of the first cost of construction (including lands, easements, rights-of-way, and relocations) allocated to environmental quality features, currently estimated to be $70,000 cash or in-kind contribution;

4. Prior to construction, non-Federal interests will furnish 25 percent of the first cost of construction (including lands, easements, rights-of-way, and relocations) allocated to environmental features, currently estimated to be $700,000 cash or in-kind contribution;

5. Prior to construction, the state of Missouri will furnish 5 percent of the first cost of construction (including lands, easements, rights-of-way, and relocations) allocated to recreation features, currently estimated to be $230,000 cash or in-kind contribution;

6. Prior to construction, non-Federal interests will furnish 50 percent of the first cost of construction (including lands, easements, rights-of-way, and relocations specifically acquired or accomplished for recreation) allocated to recreation features, which contribution must at least equal or exceed the cost for recreation lands, easements, rights-of-way, and relocations, currently estimated to be $2,330,000 cash or in-kind contribution;

7. Local interests will hold and save the United States free from damages due to the construction works, exclusive of damages due to the fault or negligence of the United States or its contractors;

8. Local interests will maintain and operate all the flood control works as constructed, in accordance with regulations prescribed by the Secretary of the Army;

9. Local interests will prevent encroachments that might adversely affect the flood-carrying capacities of the existing and proposed channels and floodways within the limits of the project;

10. Local interests will regulate the construction of significant structures that may be located in the flood plain such as bridges, landfills and channel modifications, with the intent to

promote positive contributions and prevent adverse impacts upon the hydrologic/hydraulic characteristics of the plan of improvements.

11. At least annually, local interests will inform each structure owner and occupant within the 100-year flood plain area (i.e., 1 percent probability flood plain area) by formal written notification that the improvements do not prevent, but only reduce, flood susceptability;

12. Local interests will comply with the requirements of Public Law 91-646, Uniform Relocations Assistance and Real Property Acquisition Policies Act of 1970;

13. Local interests will operate, maintain, and replace without expense to the Federal Government, the environmental and recreation areas and all facilities installed pursuant to the agreement;

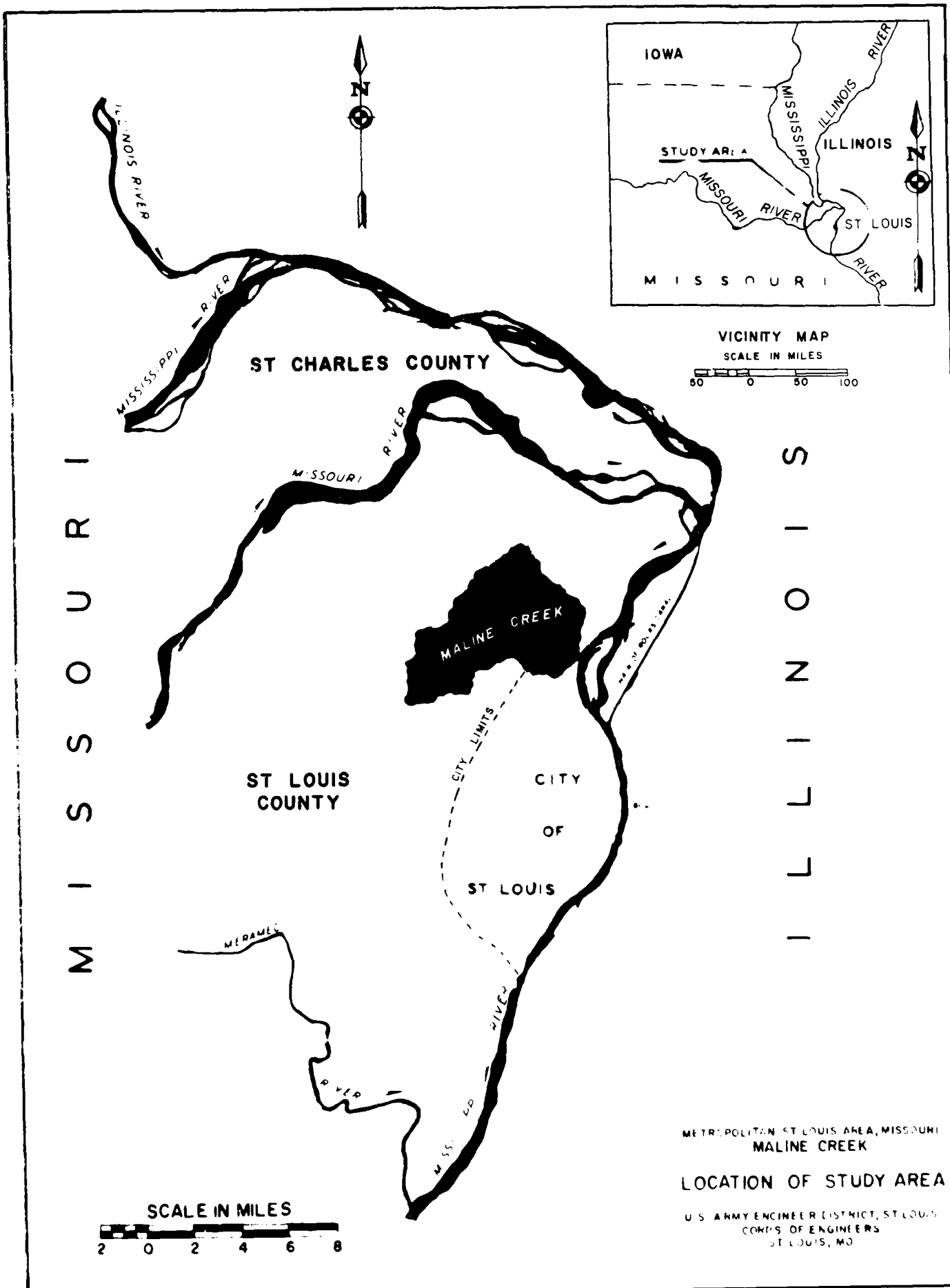
14. Local interests will assure access to the environmental and recreational facilities to all on an equal basis;

15. Local interests will comply with the provisions of Section 221 of the Flood Control Act of 1970, Public Law 91-611; and

16. Local interests will adopt, enforce and adhere to a sound comprehensive plan for flood plain management and appropriate flood plain use for the overflow areas of the incorporated and unincorporated areas involved.

Robert J. Dacey

ROBERT J. DACEY
Colonel, CE
District Engineer



METROPOLITAN ST LOUIS AREA, MISSOURI
MALINE CREEK

LOCATION OF STUDY AREA

U.S. ARMY ENGINEER DISTRICT, ST LOUIS
CORPS OF ENGINEERS
ST LOUIS, MO

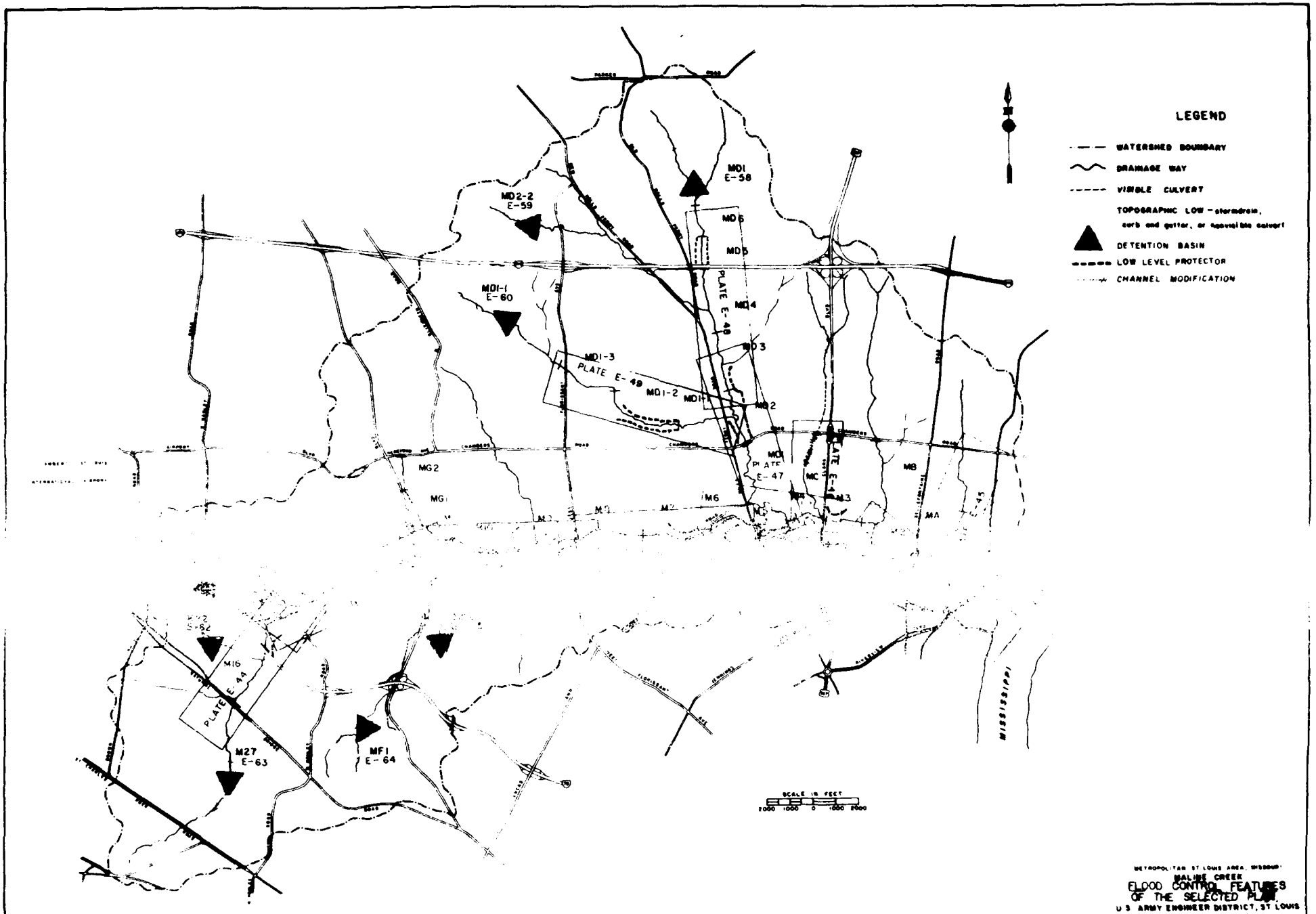

LEGEND
WATERSHED BOUNDARY
DRAINAGE WAY
VISIBLE CULVERT
TOPOGRAPHIC LOW - storm drain, curb and gutter, or nonvisible culvert
DETENTION BASIN
LOW LEVEL PROTECTOR
CHANNEL MODIFICATION
MDI E-58
MD2-2 E-59
MD6
MD5
MD4
MD3
MD2
MDI-1 E-60
MDI-3
PLATE E-49
MDI-2
MDI
PLATE E-47
MC
MB
MA
MG2
MG1
M6
M5
M4
M3
M2
M1
PLATE E-48
M16 E-62
PLATE E-44
M27 E-63
MF1 E-64
MISSISSIPPI
SCALE IN FEET
2000 1000 0 1000 2000
DOUGLAS PHOTOGRAPHIC INTERPRETATION CORPORATION
METROPOLITAN ST LOUIS AREA, MISSOURI
MALINE CREEK
FLOOD CONTROL FEATURES OF THE SELECTED PLAN
U S ARMY ENGINEER DISTRICT, ST LOUIS
CORPS OF ENGINEERS
ST LOUIS, MO

PLATE 2

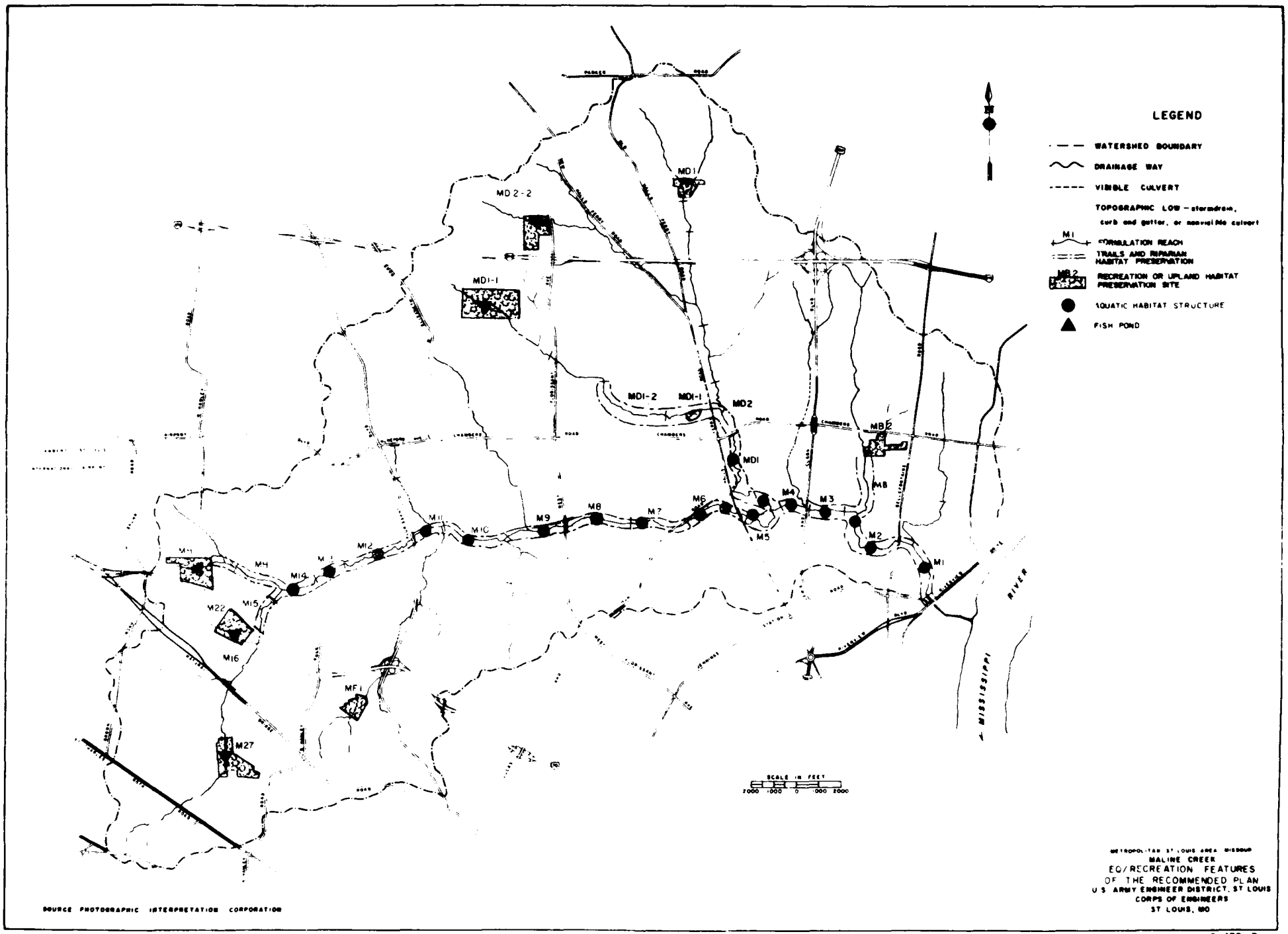

LEGEND
WATERSHED BOUNDARY
DRAINAGE WAY
VISIBLE CULVERT
TOPOGRAPHIC LOW – stormdrain, curb and gutter, or nonvisible culvert
M1 FORMULATION REACH
TRAILS AND RIPARIAN HABITAT PRESERVATION
MB2 RECREATION OR UPLAND HABITAT PRESERVATION SITE
AQUATIC HABITAT STRUCTURE
FISH POND
MD1
MD2-2
MD1-1
MD1-2
MD2
MB2
M8
M7
M6
M5
M4
M3
M2
M1
M9
M10
M11
M12
M13
M14
M15
M16
M22
MF1
M27
MISSISSIPPI RIVER
SCALE IN FEET
2000 1000 0 1000 2000
SOURCE PHOTOGRAPHIC INTERPRETATION CORPORATION
METROPOLITAN ST LOUIS AREA MISSOURI
MALINE CREEK
EQ/RECREATION FEATURES
OF THE RECOMMENDED PLAN
U S ARMY ENGINEER DISTRICT, ST LOUIS
CORPS OF ENGINEERS
ST LOUIS, MO

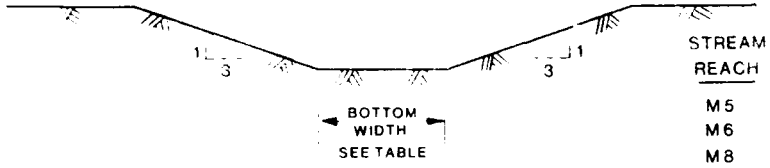
PLATE 3

MALINE CREEK

RECOMMENDED PLAN

PRINCIPLE FLOOD CONTROL FEATURES

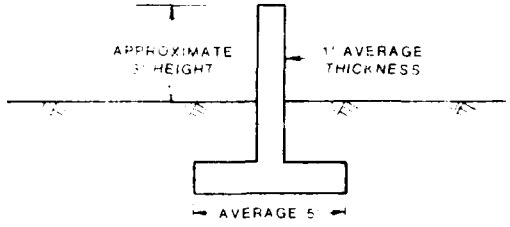
TRAPEZOIDAL EARTH CHANNELS
TOTAL 3.29 MILES LENGTH



STREAM REACH	TYPICAL BOTTOM WIDTH (FEET)
M5	40
M6	85
M8	85
M10	85
M12	30
M13	30
MC	3

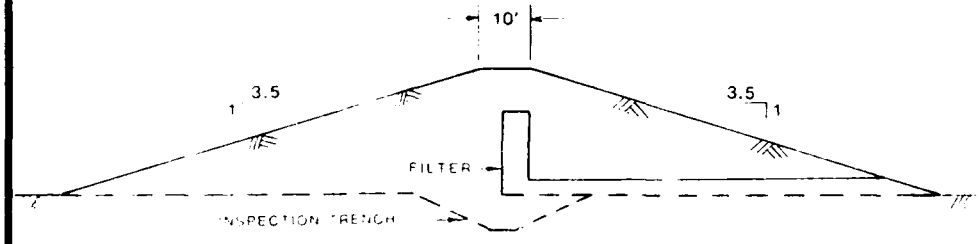
SEE PLATE E-51 FOR DETAILS

LOW LEVEL CONCRETE FLOODWALLS
TOTAL 5.05 MILES LENGTH



SEE PLATES E-39 THRU E-50 FOR LOCATIONS

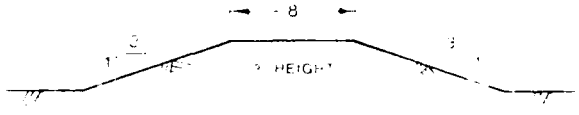
EARTH DETENTION STRUCTURES (DAMS)



DETENTION SITE	MAXIMUM SURFACE AREA (ACRES)	MAXIMUM STORAGE (ACRE/FEET)	DAM HEIGHT ABOVE STREAM BED (FEET)
M 27	63	942	29
M 22	16	215	26
MH 1	20	277	37
MF 1	30	514	27
MF 2	6	56	30
MD 1	10	52	19
MD 2-2	30	407	26
MD 1-1	52	786	26

SEE PLATES E-58 THRU E-66 FOR DETAILS

LOW LEVEL EARTH LEVEES
TOTAL 3.31 MILES LENGTH



SEE PLATES E-39 THRU E-50 FOR LOCATIONS

METROPOLITAN ST. LOUIS AREA, MISSOURI
MALINE CREEK
TYPICAL STRUCTURAL SECTIONS

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PLATE 4

FINAL

ENVIRONMENTAL IMPACT STATEMENT

WATER RESOURCES INVESTIGATION
ST. LOUIS METROPOLITAN AREA, MISSOURI AND ILLINOIS
MALINE CREEK
ST. LOUIS COUNTY, MISSOURI

This Environmental Impact Statement was prepared by
the U. S. Army Corps of Engineers, St. Louis District,
the responsible lead agency

Abstract: A plan of improvements is recommended for Maline Creek, Missouri, to address flood control, environmental quality, and outdoor recreation needs and opportunities

Review comments pertaining to this Draft Environmental Impact Statement must be received by 4 August 1980

For further information contact:
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U. S. Army Engineers
210 N. 12th Street
St. Louis, Missouri 63101

Commercial Phone 314/263-5711
FTS: 273-5711

LIST OF PREPARERS
Interdisciplinary Planning Team

The following persons were primarily responsible for preparing this Environmental Impact Statement and related study documents:

Name	Expertise	Experience	Professional Discipline
Bader, Frederick R.	Hydrologic/Hydraulic Engineering	2 yrs. Mo. State Highway Dept.; 9 yrs. St. Louis District Corps of Engineers	Civil Engineer
Brady, John T.	Terrestrial Ecology	7 yrs. with the St. Louis District as Wildlife Biologist	Wildlife Biologist
Clinton, Melbourne L.	Real Estate Appraiser	20 yrs. real estate sales & appraisal, private industry; 3 yrs. real estate appraisal, Illinois Hwy. Dept.; 2 yrs. real estate appraisal, St. Louis District	Appraiser
Dierker, John W.	Design/Cost Estimating	12 yrs. Design Engineer; 6 yrs. Cost Estimator; St. Louis District Corps of Engrs.	Civil Engineer
Ewing, Edward A. (Plan Formulator)	Water Resource Planning	6 yrs. with St. Louis District; 2 yrs. experience local planning agencies	Economics
Hamilton, Lawrence E.	Engineering	20 yrs. with Corps of Engineers, 4 yrs. as a Civil Engineer, St. Louis District	Civil Engineer
Mariolesen, Roy M.	Recreation & Land Use	29 yrs. as a Landscape Architect; 13 yrs. work with Park Depts. & St. Louis District Corps of Engineers	Landscape Architect
Rapland, Daniel J. (EIS Coordinator)	Aquatic Ecology	7 yrs. fisheries research, Mo. Dept. of Conservation; 5 yrs. EIS studies, St. Louis District Corps of Engineers	Fishery Biologist
Rapuska, E. David (Overall Study Manager)	Urban Planning	20 yrs. with Corps of Engineers; 11 yrs. in Urban Planning, St. Louis District	Geological Engineer
Rodakowski, Faro R. (Plan Formulator)	Regional Economics	7 yrs. Regional Economist/Planner, St. Louis District Corps of Engineers	Regional Economist
Wolff, Thomas F.	Foundation Engineering	9 yrs. Civil Engineer, St. Louis District Corps of Engineers	Civil Engineer
Yarbrough, Ronald [illegible]	Geology-Soils	6 yrs. Geologist, St. Louis District Corps of Engineers; 16 yrs. Assoc. Professor, Dept. of Earth Sciences & Planning, Southern Illinois Univ., Edwardsville	Geologist

Acknowledgements

The above list of planning team members does not do justice to the multitude of other individuals who have contributed to these study documents. This study, [illegible] since 1968, and during that interval literally thousands of persons from many agencies and organizations or concerned individuals have made [illegible] in the form of authorization; inventory and problems and needs studies; consultation and review; word processing, typing, and printing assistance. Their contribution must be and is hereby acknowledged.

ENVIRONMENTAL IMPACT STATEMENT

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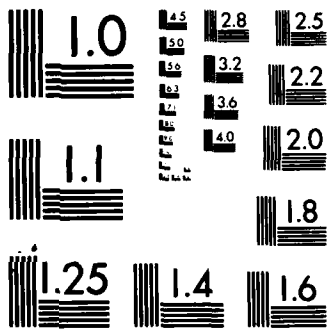

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ENVIRONMENTAL IMPACT STATEMENT

SUMMARY

Major Conclusions and Findings

The recommended plan serves to moderate the tide of continuing intensive urbanization and to some degree restore a more naturally oriented environment. These impacts are primarily limited to the flood prone areas of the Maline Creek watershed.

Areas of Controversy

No areas of significant controversy remain unresolved. This situation may arise due to the intensive existing urbanization which leads to the recommended practical approach of simply minimizing future flood plain development plus restoration of more natural amenities. The competition between use of the flood plain areas by humans versus other animals was harmoniously resolved by focusing on a combined environmental quality and outdoor recreational plan of utilization.

Unresolved Issues

No significant issues remain unresolved. The observation can be made that precluding flood plain development for Maline Creek does not insure that the alternative development sites are less environmentally critical. In all likelihood, the displaced development will directly add to continuing urban sprawl with all its negative environmental effects. No means for regulating the development sites that are the most likely alternative to Maline Creek flood plain development were considered appropriate to this survey report.

Relationship to Environmental Requirements

The detailed plans developed during the final iteration were subjected to a review of their compliance with certain environmental regulations and directives. Both the NED and EQ plans were found to be in full compliance with the policies that were reviewed, both in terms of actions to date and in planned future actions during project implementation, as shown in TABLE 14.

Executive Order 11990, Protection of Wetlands, is listed as in full compliance simply to show that it was given consideration during the review process, even though no wetlands are located in the project area. For the same reason, the plans were adjudged to be in full compliance with the Council on Environmental Quality Memorandum on Prime and Unique Farmlands, even though no such resources are located in the project areas.

NEED FOR AND OBJECTIVES OF ACTION

Study Authority

Congressional authority has directed that a study of the flooding and allied problems be accomplished for the Maline Creek drainage area. This authority was requested by the St. Louis Metropolitan Sewer District and the East-West Gateway Coordinating Council in response to severely damaging flood events.

Public Concerns

The general public has indicated many times their intensive concern regarding flood damage losses and property damage due to stream bank erosion.

TABLE 14
MALINE CREEK
RELATIONSHIP OF PLANS TO ENVIRONMENTAL REQUIREMENTS

REGULATION	NED PLAN	EQ PLAN
Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. Council on Environmental Quality, 29 November 1978	Full compliance	Full compliance
Clean Water Act of 1977 (PL 92-500; Sect. 404)	Full compliance	Full compliance
Executive Order 11988, Flood plain Management, 24 May 1977	Full compliance	Full compliance
Executive Order 11990, Protection of Wetlands, 24 May 1977	Full compliance	Full compliance
Analysis of Impacts on Prime and Unique Farmlands in EIS. Council on Environmental Quality Memorandum, 30 August 1976	Full compliance	Full compliance
Endangered Species Act of 1973, as Amended	Full compliance	Full compliance
Principles and Standards for Planning Water and Related Land Resources. Water Resources Council, 10 November 1973	Full compliance	Full compliance
Executive Order 11593, Protection and Enhancement of the Cultural Environment, 13 May 1971	Full compliance	Full compliance
River and Harbor and Flood Control Act of 1970. Public Law 91-611, Section 122	Full compliance	Full compliance
National Historic Preservation Act of 1966, as Amended	Full compliance	Full compliance
Fish and Wildlife Coordination Act of 1958	Full compliance	Full compliance

* The EQ plan is the recommended plan

Planning Objectives

The identified problems of the Maline Creek watershed have been translated into the following objective statements.

a. Reduce the future economic losses and social disruption caused by flash flooding along Maline Creek.

b. Increase outdoor recreational opportunities.

c. Maintain or improve the existing aesthetic and environmental qualities of the watershed.

ALTERNATIVES

Plans Eliminated from Further Study

An extensive screening process was used to eliminate poor alternatives, and focus study resources on the best alternatives. The screening criteria included decision criteria in the fields of economics, public acceptability, social well-being, environmental concerns, and institutional analysis. This screening process is the basis for plan formulation as described in this survey report.

Without Condition (No Action)

The base conditions used to correctly identify this potential project's impacts are the future conditions without proposed improvements. Proper analysis therefore requires a clear judgment regarding the physical, social, and economic conditions most likely to exist during the life of the proposed project. The project life has been taken as 100 years, over an assumed time frame of say 1990 to 2090. The conditions expected to exist during that future time

frame seem to be relatively easy to accurately project due to the nearly complete existing urbanization. All indications point toward essentially total urbanization in the near future.

Plans Considered in Detail

Plans were considered in detail from a field of 517 alternatives. These plans successfully passed the screening tests applied during earlier plan formulation iterations. The costs and benefits for the NED and EQ plans were verified and expanded to full survey report detail.

Comparative Impacts of Alternatives

The environmental effects of the NED and EQ plans are discussed in detail in APPENDIX B. A brief review of the net environmental effects on significant resources and the economics of the NED and EQ recommended plans, as well as the "no project" alternatives, is presented in TABLE 15.

AFFECTED ENVIRONMENT

Environmental Conditions

Physical Elements. The Maline Creek watershed covers 16,170 intensely urbanized acres (25 square miles). This area includes a small part of the city of St. Louis, portions of unincorporated St. Louis County, and all or parts of 22 municipalities within north St. Louis County (PLATE 1).

The topography of the watershed is predominantly characterized by gently sloping surfaces. The principal soil material over bedrock is a wind-deposited loess. Bedrock is usually shale located well below the creek bottom, varying from a depth of 5 to 10 feet near the headwaters to 25 feet or more along the main channel.

TABLE 15
MALINE CREEK
NET ENVIRONMENTAL EFFECT OF ALTERNATIVE PLANS

Environmental Resource	ALTERNATIVE (7-1/8%) No Project	NED Plan	EQ Plan (Selected Plan)
Physical Elements:			
Soils	Continued stream bank erosion and bottom degradation	Reduced stream bank erosion and bottom degradation	Reduced stream bank erosion and bottom degradation
Water Quality	Improved (EPA program)	Improved (EPA program, plus NED plan features)	Improved (EPA program, plus NED plan features)
Biological Elements:			
Aquatic Ecosystem	Possible improvement, due to improved water quality	Possible improvement, due to improved water quality	Increased habitat diversity - 5 fish ponds + 18 instream habitat structures
Terrestrial Ecosystem	Continued degradation	Preservation of recreation areas	Preservation of good-to-excellent wildlife habitat plus enhancement from 5 ponds
Cultural Elements:			
Population Character	Moderately dense urban area	Less use of for development purposes	Less use of for development purposes
Land Use for development	Continued use of flood plain for development	Less use of flood plain for development purposes-more recreational use in flood plain	Less use of flood plain for development purposes-more recreational use in flood plain

R 3/17/82

TABLE 15 (Continued)
MALINE CREEK
NET ENVIRONMENTAL EFFECT OF ALTERNATIVE PLANS

Environmental Resource	ALTERNATIVE (7-1/8%) No Project	NED Plan	EQ Plan (Selected Plan)
Leisure	943-acre shortage in park land by 2020	Adds 858 acres of land and 536,000 user days of annual recreation	Adds 858 acres of land and 536,000 user days of annual recreation
Noise	65 dBA's average urban area	85 dBA's will be experienced during construction in localized areas	85 dBA's will be experienced during construction in localized areas
Archaeological Sites	None affected	Possible disturbance of deeply-buried sites	Possible disturbance of deeply-buried sites
Community Cohesion	Periodically disrupted by flooding	This plan will reduce annual flooding by 89%	This plan will reduce annual flooding by 91%
Health, Safety and Welfare	Periodic flooding; major damages at larger flood events	89% annual damage reduction; 50% reduction in damages from a 100-year flood	91% annual damage reduction; 50% reduction in damages from a 100-year flood
Aesthetics	Creek and surrounding areas need cleaning and more park/open space needed	Creek cleared of debris, park and open space are major factors	Creek cleared of debris, park and open space are major factors. Also added fish ponds

R 3/17/82

TABLE 15 (Continued)
MALINE CREEK
NET ENVIRONMENTAL EFFECT OF ALTERNATIVE PLANS

Environmental Resource	ALTERNATIVE (7-1/8%) No Project	NED Plan	EQ Plan (Selected Plan)
Displacements	Annual damages will force some people from homes-abandonment	74 structures displaced for easements, rights-of-way and non-structural measures	74 structures displaced for easements, rights-of-way and non-structural measures
Housing	Continued periodic damages	Damages reduced by 89%	Damages reduced by 91%
Growth	Ambient conditions prevail	1,533 man-years of employment generated; $77,000,000 in business revenue	1,533 man-years of employment generated; $77,000,000 in business revenue
Tax Revenue	No change	$770,000 additional tax revenue from construction purchases	$770,000 additional tax revenue from construction purchases
Property Value	1,500 depressed housing values to homes in the flood plain	Average value increase in flood plains will be $1,500	Average value increase in flood plains will be $1,500
Economics			
Annual Damages	$4,145,000	$ 441,000	$ 392,000
F.C. Benefits	0	3,704,000	3,753,000
Rec/EQ Benefits	0	1,059,000	1,059,000
Redev. Benefits	0	0	0

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TABLE 15 (Continued)
MALINE CREEK
NET ENVIRONMENTAL EFFECT OF ALTERNATIVE PLANS

Environmental Resource	ALTERNATIVE (7-1/8%) No Project	NED Plan	EQ Plan (Selected Plan)
Total Benefits	0	4,763,000	4,812,000
Total Costs	0	3,324,000	3,574,000
Net Benefits	0		
BCR	0	1.43	1.35

The principal surface drainage system totals 36.2 miles and consists of 10.6 miles of Maline Creek main channel and 10 major tributaries with lengths varying from 1.4 to 4.2 miles. Headwater channels are predominantly storm sewers, some concrete-lined and some inclosed in culverts, which flow into open channels that reach a maximum size of 25-foot depths and 100-foot widths near the mouth. Water quality in different reaches and different seasons ranges from fair to poor.

The study area has four distinct seasons, normally without prolonged periods of extreme cold, heat, or relative humidity. The average yearly temperature is 55°F, while the average maximum summer temperature is 90°F. Average annual precipitation is 35.4 inches. The watershed is generally in compliance with Federal air quality standards.

Biological Elements. Lentic habitat within the Maline Creek watershed consists of several small ponds ranging in size from 1 to 6 surface acres. Some of the ponds have fish populations. Poor water quality and a lack of habitat diversity limit the variety of aquatic organisms that occur in the creek to pollution-tolerant forms.

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Cover in the watershed varies in wildlife habitat value from the low-valued monoculture of manicured lawns to a high-value, diverse interspersion of trees, grass, and shrubs. Most of the natural vegetation that remains is forest cover concentrated in the northern portion of the watershed on steep slopes and along stream courses.

Cultural Elements. The major land use categories in the watershed and their respective total acreages as of 1975 are as follows: residential, 10,141 (62.7 percent); commercial-industrial, 1,146 (7.1 percent); public-recreation, 2,062 (12.8 percent); and agriculture-vacant, 2,821 (17.4 percent). There are 737 acres of park land, reflecting an unmet existing need for recreation land of 515 acres.

Selected 1970 population characteristics are as follows: percent black, 5.4; median age, 28.0; median years of education, 12.0; percent civilian labor force employed, 95.9; median income, $11,628; percent families below poverty level, 3.7; and median value of owner-occupied housing, $16,900. At the time of the 1970 Census, the population of the watershed was 125,330 (a 20 percent increase from 1960).

Due to the watershed's location within a highly urbanized area, it is affected by several noise pollution sources, most notably from highways and air traffic.

Extensive urbanization has destroyed all but an insignificant portion of the archaeological record within the watershed. One local historic site, the Bissel House, is on the National Register of Historic Places.

SIGNIFICANT RESOURCES

Physical Elements

Soils. The principal soil in the watershed is wind-deposited loess. Its significance in this project area is derived from its erosive nature. Both stream bank erosion and stream bottom degradation were recognized during early iterations as potential problems. Both the NED and EQ plans include features for control of these problems.

Water Quality. Excessive measurements of pH, dissolved oxygen, nutrients, chloride, and heavy metals were found during the inventory effort for this report. It is expected that these conditions will improve during the next decade because of the Environmental Protection Agency's implementation of water pollution control plans in the area. Some ancillary benefits to water quality may be derived from NED plan or EQ plan features. However, the significance of this element is primarily derived from the Clean Water Act, Section 404, analysis required for this project. A complete discussion of the Section 404 requirements is given in APPENDIX J.

Air Quality. This element was considered during the environmental inventory, in accordance with requirements of Secton 122 of the River and Harbor and Flood Control Act. The watershed was generally in compliance with air quality standards. The effect of NED and EQ plans on air quality is discussed in APPENDIX B. No long-term effects would be expected from either plan, so this element was not included in TABLE 15 comparative impacts.

Biological Elements

Aquatic Ecosystem. Several environmental regulations, including the Fish and Wildlife Coordination Act, the National Environmental Policy Act, and Principles and Standards for Planning Water and Related Land Resources, require that fish and wildlife habitat be given consideration for possible preservation or enhancement opportunitities in such projects. This was done during each planning iteration of this project. During the inventory, several small ponds were located in a scattered array throughout the watershed, most of which suffer from siltation and excessive nutrient levels. The inventoried lotic habitat consists of 36.2 miles of Maline Creek main channel and tributaries. With one exception, the fish community in stream reaches consists almost entirely of fathead minnows, a pollution-tolerant species. The NED plan provides for mitigation of stream habitat destruction. The EQ plan provides for enhancement of aquatic habitat.

Terrestrial Ecosystem. The wildlife habitat was also given consideration during each planning iteration. During the inventory, it was determined that most of the natural vegetation in the watershed has been replaced by urbanization. The largest amount of vegetative cover is mixed surburban, covering 77 percent of the watershed. The undeveloped, natural vegetation that remains in the watershed is mostly forest cover concentrated in the northern portion of the watershed on steep slopes and along stream courses. Both the NED and EQ plans provide for preservation of the good-to-excellent quality wildlife habitat.

Cultural Elements

Land Use. The only significant land use change will be the conversion of much of the 10-year flood zone acreage from

development to recreation, EQ, and open space purposes. About 858 acres will be taken out of urban use and turned into linear parks, trails, and picnic areas.

Leisure. The NED and EQ plans will contribute 858 acres of open space to the area's expected 2020 deficiency of 943 acres. Both plans would add 273,000 annual user-days of recreation opportunity. These added recreation features will go a long way in relieving the expected park shortage, needs, and problems.

Noise. Average noise levels for a typical urban area are in the order of 65 dBA's. During construction certain localized areas may experience short-term noise levels of 85 dBA's. This information is required by Public Law 91-611, Section 122. The data apply to both the EQ and NED plans.

Community Cohesion. Since the NED and EQ plans reduce annual damages by 92% and 93%, respectively, there should be a marked improvement in community cohesion. This information is required by Public Law 91-611, Section 122.

Health, Safety and Welfare. This information is not required but is considered important. Damages and the health, safety, and welfare difficulties associated with high magnitude floods are substantially reduced. The EQ plan provides somewhat better protection for greater magnitude floods.

Aesthetic. Greatly improved open space, EQ features, and recreation may improve aesthetics. Total acreage contributed to these purposes is 858. This is significant and the information is required by Public Law 91-611, Section 122.

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Displacements. Displacements affect social well-being. There will be 74 homes displaced (fee simple purchase) with either the NED or EQ plans. This information is required by Public Law 91-,611, Section 122.

Displacement of Farms. There are no displaced farms associated with either the NED or EQ plan. This information is required by Public Law 91-611, Section 122.

Housing. Annual damage reductions with the NED and EQ plans are 92% and 93% respectively. This marks a significant positive impact in reducing damages to housing.

Growth. A spin-off of a multi-purpose project in the added employment and income generated as a result of civil works expenditures. Either alternative (NED/EQ) generates about 1,533 man-years of work and $77,000,000 in business activity with required multi-purpose efforts. Ths information is required by Public Law 91-611, Section 122, and is a substantial impact in and of itself.

Industrial Activity. Same impacts and rationale as Growth.

Employment/Labor Force. Same impacts and rationale as Growth.

Tax Revenue. Regional income would increase by $77,000,000 during the construction period. A tax revenue increase during the same period is expected to be about $770,000. These effects are expected to have regional impacts. This information is required by Public Law 91-611, Section 122, and is important information for local governments.

Property Values. Homes in the flood plain are depressed locally on the average by about $1,800 per structure. The NED and EQ

alternatives reduce annual flood damages by 92% and 93%, respectively, and consequently increase housing values overall by about $1,500 per structure.

Public Facilities/Services. The NED and EQ plans both create eight dry detention sites and a system of trails. These are public facilities which have associated public service. They have a flood control element and a recreation component, for example, flood storage, picnicking, hiking, bicycling, and trails. The EQ plan in addition creates five fish ponds for EQ purposes.

Archaeological Sites. No significant archaeological sites were identified in the watershed during the cultural resources survey. However, it is recognized that deeply-buried sites may be discovered during construction of the project. All subsurface excavations would be monitored by a qualified field archaeologist during implementation of either the NED or EQ plan.

ENVIRONMENTAL EFFECTS

The environmental effects of the NED and EQ plans are discussed in detail in APPENDIX B. Separate discussions of endangered species and Clean Water Act elements are included in APPENDICES I and J, respectively. The net impacts on significant resources are briefly tabulated in the Comparative Impacts of Alternatives section of this EIS.

PUBLIC INVOLVEMENT

The public involvement program is based on three levels of public information dissemination. The first level of information is the general public. Many meetings, both formal and informal, were supplemented with news releases and media coverage. The second

level of public participation was based on a technical stormwater advisory committee. This committee consisted of members of the local technical community, and representatives of the St. Louis Chapter of the American Society of Civil Engineers, Registered Professional Engineers, American Planning Association, East-West Gateway Coordinating Council, St. Louis County Government, private industry and the general citizenry. The third level of coordination was focused on elected officials primarily through the St. Louis Council and the city of St. Louis. The last level of coordination also included all governmental agency cooperation.

Required Coordination

Required coordination necessary to seek authorization for eventual implementation of a solution has been specified in the Summary Report paragraph entitled REMAINING WORK AND TIME SCHEDULE.

Statement Recipients

One hundred seventy-six copies of the Draft Survey Report and Environmental Impact Statement was furnished to the following agencies, organizations, and individuals for review and comment:

U.S. House of Representatives (6 copies)
- Honorable William Clay
- Honorable Robert A. Young
- Honorable Harold L. Volkmer

U. S. Senate (4 copies)
- Honorable John C. Danforth
- Honorable Thomas F. Eagleton

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Public Views and Responses

In general, the single predominant theme of all public views and responses has been centered around how soon the improvements can be installed. The problems of erosion and flooding have been studied for such a long time that all study participants are anxious for construction to begin. The plan of improvement is clearly a good one, minimizing long-standing water resource problems and enjoying repeated total local support. The only criticism, and it has been voiced frequently and forcefully, has dealt with the long time required to implement this much-needed plan under the normal Corps of Engineers procedures and funding restraints.

INDEX, REFERENCES, AND APPENDICES

An index of the subjects discussed in the Environmental Impact Statement and the remainder of the Main Report and Appendices is given in TABLE 16, as required by EIS regulations.

TABLE 16
MALINE CREEK
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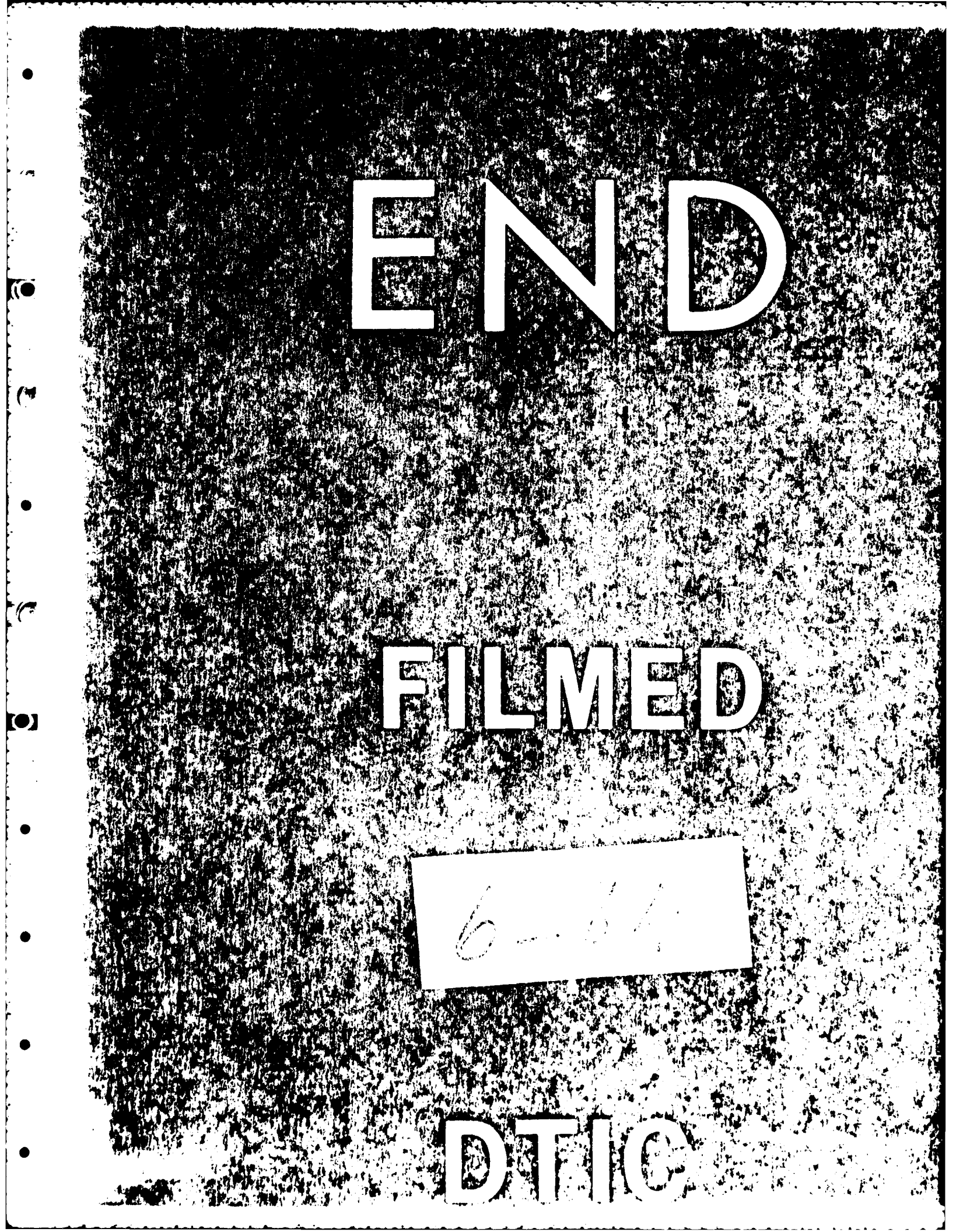
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